THE WEATHER AND CIRCULATION OF FEBRUARY 1958 [1]

A Month With an Expanded Circumpolar Vortex of Record Intensity

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1. HIGHLIGHTS

February 1958 will long be remembered as a month of contrasting weather extremes in many parts of the United States. Many established records of long standing were broken—for cold in the Southeast, warmth in the Northwest, snow along the Gulf and Atlantic coasts, precipitation in the Great Plains and along the west coast, and dryness in the Mid-West. During the last week of the month intense cyclonic activity was responsible for new low barometer readings at many stations in the central United States, as well as for tornadoes, blizzards, and floods over a wide area.

Abnormalities of the weather were produced by corresponding abnormalities in the circulation pattern. Strong blocking ridges over Greenland and Alaska were accompanied by the deepest mean troughs on record along the east coast and in the eastern Pacific. A typically "low index" circulation prevailed throughout the Western Hemisphere as the polar anticyclones intensified and the subtropical anticyclones weakened. This was part of a great index cycle in which the prevailing westerlies of middle latitudes were displaced southward to the subtropics, where they blew with unprecedented speed in the form of an expanded and intensified circumpolar vortex.

2. LONG-PERIOD BACKGROUND

The profile of the general circulation underwent a striking metamorphosis during the 1957–58 winter. This transition is well illustrated by figure 1, a time-latitude section of zonal wind components at the 700-mb. level averaged over the Western Hemisphere on a series of overlapping 30-day mean charts prepared about the 1st and 16th of each month. The principal axis of maximum westerly wind speed or mean "700-mb. jet stream" (delineated by the heavy solid curve) was located around 45° N. throughout the months of November and December 1957. This was 2° to 5° north of its latitude on normal maps during these months (denoted by the dashed curve). During January 1958 the axis of maximum westerlies moved rapidly southward on a mean basis and reached a minimum latitude of approximately 31° N. by the end of the month, some 8° south of its normal latitude at this time of year. The westerlies remained depressed throughout February, and it wasn't until early March that the jet axis appeared as far north as 33°. In accordance with the classical concept of the expanded circumpolar vortex [1], the westerlies intensified as they moved south, attaining an extremely high value of 16 meters per second just before mid-February around 32° N.

The southward displacement of the westerlies during the 1957–58 winter was part of a great index cycle which displayed many of the characteristics described by Namias [2], except that it occurred about a month before the preferred time of year. This cycle is well illustrated by the upper curve in figure 2 giving the speed of the temperate westerlies (or zonal index) at 700 mb., averaged over the Western Hemisphere between 35° N. and 55° N., on a series of overlapping 5-day mean maps computed three times a week. After remaining above normal (dashed line) throughout December [3], the zonal index dropped sharply during the first two weeks of January, reaching a minimum on January 18 [4]. Modest recovery during the second half of January was followed by another sharp dip during the first week of February. This culminated in a remarkably low value of 3.1 meters per second for the period February 1–5. During the balance of February a gradual recovery occurred, except for a temporary drop around mid-month, and the index finally climbed above normal during the period centered on the 24th. At month's end another dip occurred, and low index extended into the first half of March.

Weakening of the westerlies at middle latitudes during January and February 1958 was compensated by strengthening of the westerlies at low latitudes. This is clearly illustrated by the lower curve in figure 2, which gives the course of the subtropical westerly index at 700 mb. (20° N.–35° N.) on a 5-day mean basis. During December 1957, while the temperate westerlies were strong, the subtropical westerlies were weaker than normal (dashed) [3]. As the former index dropped rapidly during the first half of January, the latter climbed steadily, reaching one

[1] See Charts I–XVII following p. 80 for analyzed climatological data for the month.

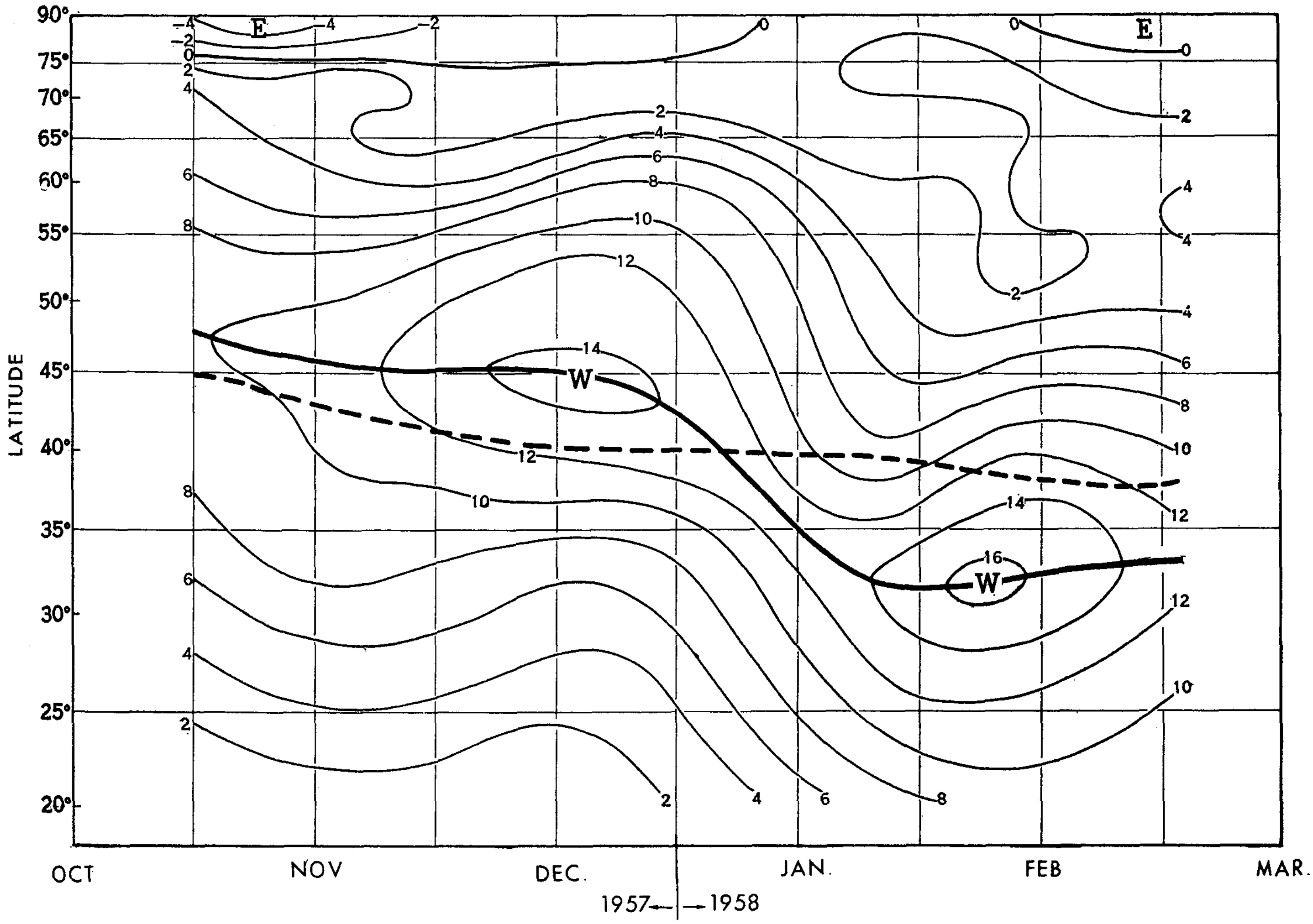

FIGURE 1.—Time-latitude section of 30-day mean zonal wind components averaged over Western Hempishere at 700 mb. Wind speeds were computed twice-monthly in 5° latitude belts from the period mid-October to mid-November 1957 until the period mid-February to mid-March 1958. Isotachs are in meters per second with easterly winds negative. Centers of maximum west wind speed are labeled W; easterly centers are labeled E. The axis of maximum westerlies (heavy solid curve) was north of its normal latitude (broken line) during the first half of the period but displaced far southward during the latter half.

maximum on the 13th and another on the 25th [4]. After some minor fluctuation during the first half of February, the most extreme maximum of the year was reached during the 5-day period centered February 17, when a value of 15.2 meters per second was observed, the highest 5-day mean subtropical westerly index on record (since May 1943). Subsequently, the subtropical westerly index declined sharply, and it finally returned to normal on March 6.

3. MONTHLY MEAN CIRCULATION

A. ZONAL WIND BELTS

The nature of the expanded circumpolar vortex during February 1958 is well illustrated by figure 3, the zonal wind speed profile for the Western Hemisphere at the 700-mb. level. The westerly jet maximum this month (solid) was located between 30° and 35° N. with a speed of 15.4 m.p.s. In contrast, the February normal (dashed) has a peak speed of 12.8 m.p.s. between 35° and 40° N. Figure 3 also shows that the westerlies were weaker than normal at all latitudes from 40° N. to 75° N. This deficit was compensated by an excess of westerly momentum from 20° to 35° N. (shaded area).

The unusual strength of the westerlies at low latitudes during February 1958, and their simultaneous weakness at middle and high latitudes, is expressed in terms of conventional indices for fixed latitude bands in table 1. The speed of the subtropical westerlies, measured between 20° and 35° N. at the 700-mb. level, averaged 13.2 m. p. s. for the month. This was 4.6 m. p. s. above the February normal and over 2 m. p. s. greater than the value observed during any previous month of record (since 1945). The other two indices at 700-mb. were not so extreme but nevertheless exhibited departures from normal in the

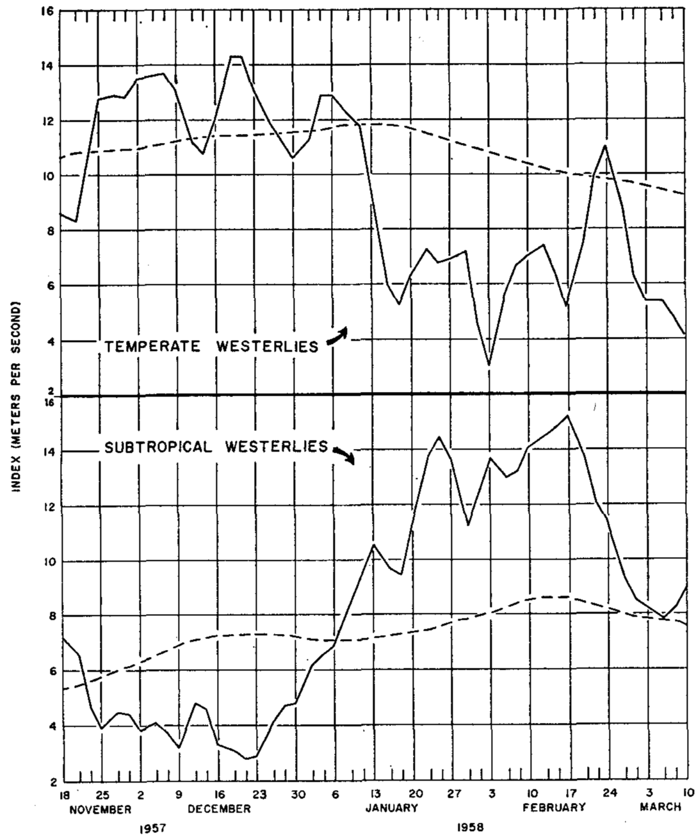

Figure 2.—Time variation of speed of 700-mb. westerlies averaged over the Western Hemisphere for temperate zone (35°–55° N.) above, and subtropical zone (20°–35° N.) below. Solid lines connect 5-day mean index values (plotted at middle of period and computed three times weekly), and dashed lines show variation of corresponding normal. Note the prolonged period of above normal subtropical westerlies, with record high value from February 15 to 19, 1958.

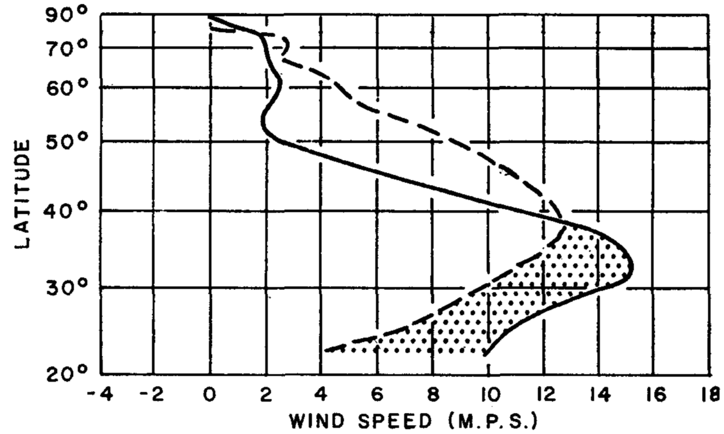

Figure 3.—Mean 700-mb. zonal wind speed profile in the Western Hemisphere for February 1958 (solid) and February normal (dashed). Westerlies were stronger than normal (stippled) at low latitudes, with a pronounced peak around 33° N.

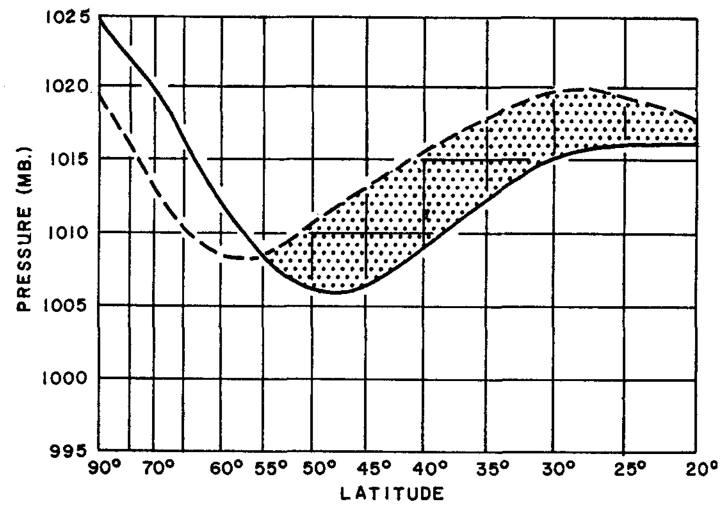

Figure 4.—Mean sea level pressure profile in the Western Hemisphere for February 1958 (solid) and February normal (dashed). Pressures were below normal (stippled) south of 55° N., but above normal to the north.

expected direction; i. e. below normal values of westerly wind speed in both temperate and polar regions.

Table 1 also contains monthly mean values of the standard indices at sea level. The prevailing westerlies of temperate latitudes (zonal index) were weaker than normal at this level, as well as at 700 mb. As is typical with a low-index circulation of this sort, the sea level easterlies were unusually strong in the polar region but much weaker than normal in the subtropics. In the latter zone (from 20° N. to 35° N.) the normal easterlies (trade winds) were replaced by strong westerlies which had a greater speed than observed during any previous month of record (since 1942).

Table 1.—*Monthly mean values of standard indices in the Western Hemisphere during February 1958 (in meters per second).*

Index	Latitude belt (° N.)	Height	Observed	Normal	Anomaly
Polar westerlies	55—70	700 mb.	1.7	3.7	−2.0
Temperate westerlies	35—55	700 mb.	7.0	10.2	−3.2
Subtropical westerlies	20—35	700 mb.	13.2	8.6	+4.6
Polar easterlies	70—55	Sea level	4.1	1.6	+2.5
Zonal westerlies	35—55	Sea level	1.2	3.4	−2.2
Subtropical easterlies	35—20	Sea level	−3.1	0.1	−3.2

The existence of west winds this month in the subtropics at sea level, instead of the conventional easterlies, can also be inferred from figure 4, the sea level pressure profile for the Western Hemisphere. Mean pressures increased with decreasing latitude from 45° N. to 20° N., and the relative maximum normally present (broken curve) around 28° N. was entirely absent. Figure 4 further shows that the subpolar minimum normally located around 57° N. was accentuated this month but displaced southward by about 10 degrees. As a result, pressures averaged below normal at all latitudes south

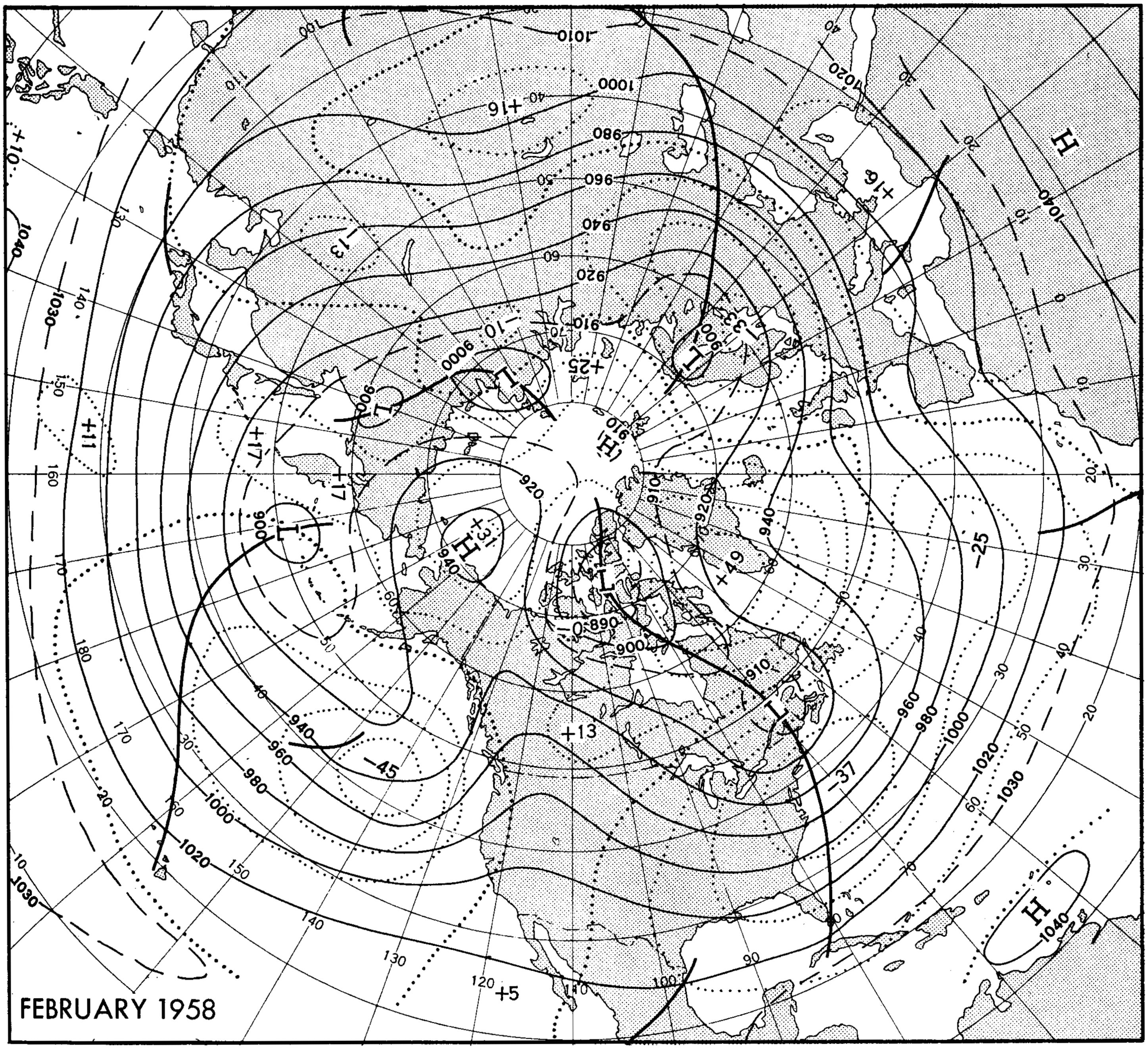

FIGURE 5.—Mean 700-mb. contours (solid) and height departures from normal (dotted) (both in tens of feet) for February 1958. Large, positive anomalies in polar regions were accompanied by an almost circumpolar ring of negative anomalies to the south.

of 55° N. (shaded area). This deficit was partly compensated by above normal pressures from 55° N. to the pole. In other words, the polar anticyclones grew at the expense of the subtropical anticyclones, so that the polar easterlies were strong but the subtropical easterlies weak (table 1). In all these respects February 1958 was typical of cases with a low zonal index and an expanded circumpolar vortex.

B. REGIONAL CHARACTERISTICS

Thus far only latitudinal averages of circulation features have been considered. The regional characteristics making up the hemispheric mean are illustrated in figure 5, the 700-mb. chart for the month of February. In its broad-scale aspects (neglecting several minor troughs), this map can be considered to have an overall wave number of three, with full-latitude troughs in the central

Pacific, eastern North America, and European Russia, and full-latitude ridges in western North America, the eastern Atlantic, and central Siberia. The principal troughs and ridges had one interesting feature in common this month; namely, the absence of the customary positive horizontal tilt from northeast to southwest. Instead most troughs and ridges were oriented either negatively, from northwest to southeast, or meridionally, from north to south. This is a logical consequence of the fact that the westerlies were extremely strong at low latitudes but very weak at high latitudes, and it is a characteristic commonly associated with low zonal index and southward transport of momentum [5].

Figure 5 contains additional features typical of low-index circulation. For example, the amplitude of the wave train over North America and adjacent oceans was unusually great. In this respect, and also with regard to its long wavelength, trough and ridge locations, negative trough tilt, and wind distribution, figure 5 resembles a model for a wave of large dimensions prepared by the author in 1952 [6]. Another typically low-index feature of figure 5 is the large number of low centers in middle and high latitudes, six in all, in contrast to the three found on the normal 700-mb. chart for February. Blocking was also very much in evidence in figure 5, as indicated by the closed High in the Arctic Ocean northwest of Alaska and the strong ridge over Greenland.

The circulation abnormalities inherent in the mean contour pattern are brought into sharper focus by the dotted lines in figure 5, expressing the departure from normal or anomaly of local 700-mb. height. In the United States the largest anomaly was −370 ft. at the mouth of Chesapeake Bay, the most extreme negative departure from normal observed in the eastern half of the United States on any monthly mean 700-mb. map of record (starting October 1932). This negative anomaly was closely associated, probably through the flux of vorticity, with an even larger one in the eastern Pacific, where monthly mean 700-mb. heights averaged 450 ft. below normal about 700 miles west of the California-Oregon coastal boundary. Simultaneous anomalies of mean 700-mb. height in these two areas (the east coast and the eastern Pacific) have been shown to be highly correlated on both 5-day mean maps [7] and monthly mean maps [8].

To the north of each of these negative anomalies was a strong positive anomaly center of the blocking variety. The first was centered over Davis Strait, where heights averaged 490 ft. above normal. The second was somewhat smaller in magnitude, with maximum departure 310 ft. above normal, northwest of Alaska. These two centers of positive anomaly formed part of a continuous girdle of above normal heights at higher latitudes encompassing the Arctic Ocean, northeastern Siberia, Alaska, Canada, and Greenland. The blocking nature of this ring of positive anomaly was emphasized by the presence of an almost circumpolar band of negative anomaly to its south, interrupted only by weak positive departures over Japan and the western United States.

The monthly mean circulation at the 200-mb. level is illustrated in figure 6. For the most part the contours resemble those at 700 mb. However, certain differences may be noted, including westward displacement of the

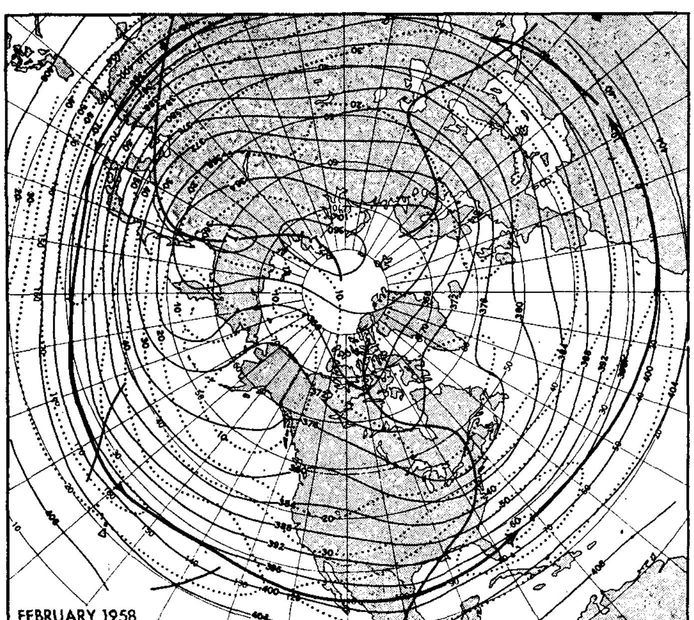

FIGURE 6.—Mean 200-mb. contours (solid, in hundreds of feet) and isotachs (dotted, in meters per second) for February 1958. Solid arrows indicate the average position of the 200-mb. jet stream which extended in a continuous axis around the hemisphere at about 25°–30° N.

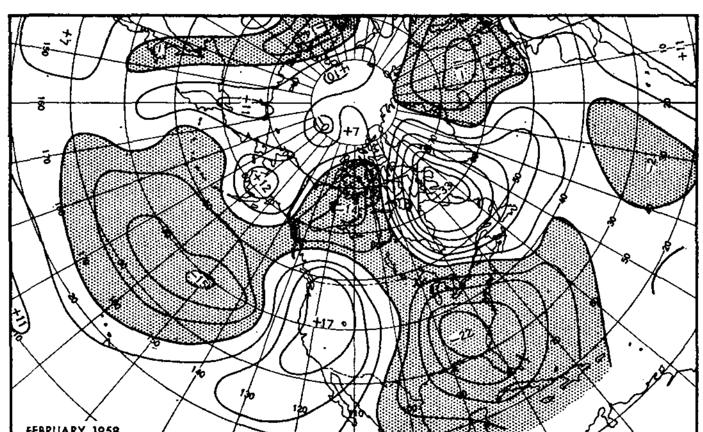

FIGURE 7.—Departure from normal of mean thickness (1000–700 mb.) for February 1958, with subnormal values shaded. Isoline interval is 50 feet, and centers are labeled in tens of feet. Outstanding features are cold air in eastern United States and western Canada, and warm air in western United States and eastern Canada.

trough in eastern North America, elimination of the closed High over northwestern Alaska, and emphasis on the trough in eastern Asia at the expense of the one in the central Pacific.

Perhaps of greater interest than the contours in figure 6 are the dotted isotachs derived from them geostrophically, as explained in a previous issue of this publication [9]. The heavy solid curves drawn through the axes of maximum (total horizontal) wind speed delineate the mean jet stream at the 200-mb. level. This jet extended in a practically continuous arc around the 25th or 30th parallel of latitude and attained maximum intensity just east of Florida and southern Japan. Thus it accurately fits the classical description of the low-index state as one with an intensified and expanded circumpolar vortex in the upper troposphere [1].

4. AVERAGE WEATHER AND ITS RELATION TO THE MEAN CIRCULATION

A. TEMPERATURE

The pattern of departure from normal of average temperature for February 1958 in the United States is portrayed by Chart I–B for the surface and by figure 7 for the layer from 1000 to 700 mb. The outstanding feature of the month was the abnormal cold in the eastern half of the country, with extreme departures of over 10F.° in much of the Southeast. This was the coldest February ever observed at Birmingham, Ala., Asheville, N. C., Greenville, S. C., Columbus, Ga., and at numerous cities in Florida including West Palm Beach, Tampa, Lakeland, and Daytona Beach. It was the coldest of any month on record at Miami, Orlando, and Fort Myers in Florida, and also at Oak Ridge, Tenn.

Because of the marked persistence of below normal temperatures in the Southeast from January [4], and to a lesser degree from December [3], the 1957–58 winter season (defined as the mean of December, January, and February) was the coldest on record at several cities in Florida (West Palm Beach, Fort Myers, Miami, Lakeland), Alabama (Mobile, Montgomery), and Georgia (Columbus). At Tampa, Fla. this winter was over 1° colder than any other winter since 1825.

The relation of February's cold weather to the monthly mean circulation was straightforward. Strong cyclonically curved northwesterly flow prevailed over the eastern half of the United States at all levels from 700 to 100 mb., as shown by figures 5 and 6 and Charts XIII to XVII. The center of negative height anomaly observed over the Middle Atlantic coast on the monthly mean 700-mb. chart (fig. 5) was record-breaking in magnitude, as previously noted, and extensive enough to produce below normal heights over the entire eastern half of the country. In the source region for cold air, over northwestern Canada, thicknesses for the month were below normal (fig. 7) and 700-mb. heights above normal (fig. 5), a combination favoring low temperatures in the eastern half of the United States [8, 10]. At sea level a strong mean High was observed in the Arctic Ocean north of Alaska (Chart XI), and pressures averaged 10 mb. above normal (Chart XI Inset). A well defined ridge of high pressure extended southeastward from the anticyclone center through northwestern Canada and the Missouri-Mississippi Valley into the Southeast. Numerous migratory anticyclones traversed this ridge along paths shown in Chart IX, each accompanied by a fresh outbreak of cold polar continental air. A final factor contributing to the cold east of the Mississippi River was the fact that in this region the mean geostrophic wind components at sea level were strongly from the north-northwest, not only in an absolute sense (Chart XI) but also relative to normal (Chart XI Inset).

The magnitude of negative departures from normal of mean temperature in the eastern United States tapered off in States along the northern border, and temperatures even averaged slightly above normal in Maine and northern Minnesota (Chart I–B). Relatively mild weather in these areas can be explained most readily in terms of the strong anomalous flow components from the east which are evident on the monthly mean chart at 700 mb. (fig. 5). Since the Atlantic Ocean is much warmer than the land in February, this flow resulted in advection of air from a relatively warm source region. A similar effect was operative throughout eastern Canada, where it was enhanced by southerly flow in the absolute sense and above normal heights at 700 mb. (fig. 5). The resulting warmth is well illustrated by the mean thickness of 330 ft. above normal on the Labrador coast in figure 7. According to the Canadian Meteorological Service, surface temperatures averaged 14 F.° above normal for the month in Goose Bay, Labrador.

Extremes of cold in the eastern half of the United States were matched by extremes of warmth in the West, particularly west of the Continental Divide. Both surface temperatures (Chart I–B) and 1000–700-mb. thicknesses (fig. 7) averaged above normal in the vast area from the western Plains to the Pacific coast. Maximum positive departures of monthly mean temperature were 10–12 F.° in northern Washington and 8–9 F.° just east of Great Salt Lake. This was the warmest February on record at Seattle, Olympia, and Walla Walla in Washington, at Portland and Eugene in Oregon, and at Eureka in California.

The warmth in the West was intimately related to the mean circulation observed during the month. Of greatest importance was the center of below normal 700-mb. height off the Oregon-California coast (fig. 5). This is the largest negative departure from normal observed in the eastern half of the Pacific on any February map of record (since 1933). It was reflected in a deep mean low at sea level (Chart XI), with pressures for the month as much as 16 mb. below normal (Chart XI Inset). The effect of the Low off the coast was enhanced by the presence of a

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mean ridge over the Great Basin at all levels of the troposphere (Charts XI to XVII), with above normal heights at the 700-mb. level (fig. 5). The circulation between these two features produced a strong onshore flow from the southwest which carried warm maritime air from the southeastern Pacific into the western United States, and prevented any cooling by continental airmasses from the north or east. The strength of this southwesterly current was much greater than normal, as indicated by the lines of equal pressure departure from normal at sea level (Chart XI Inset). It is interesting to note the striking resemblance between figure 5 and the composite map given by Martin [10] for ten 5-day mean periods of extreme warmth during winter at Eureka, Calif.

The boundary between warm maritime air in the West and cold continental air in the East was marked by a sharp frontal zone which remained quasi-stationary throughout the month just east of the Continental Divide. The location of the zone is well illustrated by figure 8, which shows that fronts were indicated on the *Daily Weather Map* in Montana and Wyoming on as many as 25 out of the 28 days in February. In the Great Plains region the axis of maximum frontal frequency coincides very closely with the line of zero surface temperature departure from normal in Chart I–B.

B. PRECIPITATION

The maritime Pacific air which dominated the Far West during February was not only extremely warm but also very moist. Orographic lifting of the moisture, in conjunction with some cyclonic and frontal activity, produced above normal amounts of precipitation in all portions of the United States west of the Continental Divide. Circulation features indicative of this precipitation, in addition to the stronger than normal southwesterly flow previously mentioned, were strong cyclonic curvature of the mean sea level isobars and below normal values of sea level pressure (Chart XI and Inset). More than twice the normal amount of precipitation fell along the northern border from central Washington to Montana, along the west coast from southern Oregon to Los Angeles, and in the region adjacent to the California-Arizona border (Chart III–B). It was the wettest February on record at Oakland, Calif., and Medford, Oreg., and the second wettest at Yuma, Ariz., and Red Bluff, Calif. At Ely, Nev., this February had the greatest average cloudiness and the least percentage of sunshine of any February on record.

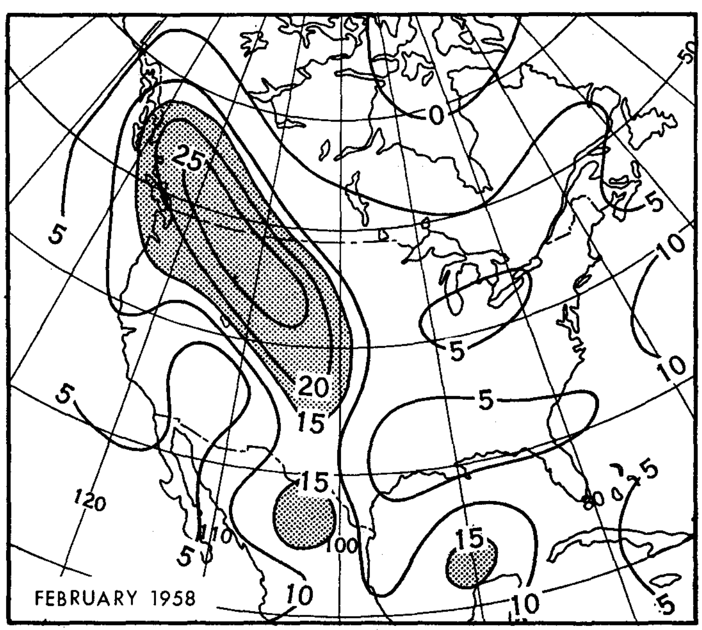


FIGURE 8.—Number of days in Feburary 1958 with fronts of any type within unit squares (with sides approximately 500 miles). All frontal positions are taken from *Daily Weather Map*, 1:00 P. M., EST. Areas with fronts on 15 or more days are stippled. Fronts were frequently located just east of the Continental Divide, separating cold continental airmasses in the East from warm maritime airmasses in the West.

Overruning of cold continental air by moist Pacific air in the vicinity of the quasi-stationary frontal zone east of the Continental Divide (fig. 8) produced copious precipitation in the Northern and Central Plains States. In addition, upslope wind components were indicated in this area by easterly mean flow relative to normal at both sea level (Chart XI Inset) and 700 mb. (fig. 5). More snow than for any other previous month was reported at Great Falls, Mont. (26.1 in.), and more than for any February of record at Goodland, Kans. As much as three times the normal amount of precipitation fell in parts of Montana, South Dakota, and Nebraska (Chart III–B), and Huron, S. Dak. recorded more precipitation than in any previous February.

More than twice the normal precipitation fell in southern Texas, from El Paso to the Gulf Coast. Brownsville had 10¼ inches, 900 percent of normal, and more than during any other February on record, while record-breaking snowfall was reported at San Antonio and Port Arthur (2.9 in.). Aspects of the monthly mean circulation associated with this precipitation included southward displacement of the jet stream, stronger than normal southerly flow at sea level, and the presence of a weak low-latitude trough and confluence zone at 700 mb. In addition, cyclonic and frontal activity were frequent in Texas on a daily basis.

Precipitation was generally in excess of normal east of the Appalachians from Florida to Maine, with record-breaking amounts at Binghamton, N. Y. More snow fell during this February than in any other month on record at Syracuse (72.6 in.), Rochester (64.3 in.), and Buffalo (54.2 in.) in New York State. Several related meteorological conditions are suggested. Monthly mean sea level pressures were 14 mb. below normal off the coast of New England and the lowest for any February on record at Newark, N. J., and Boston, Mass. Sharp cyclonic curvature of the isobars is evident on the monthly mean sea level map (Chart XI), while the relative vorticity computed from the mean 700-mb. map was strongly cyclonic and much greater than normal throughout the eastern quarter of the United States (chart not shown). Several storms moved across the Gulf States and up the east coast during the month and deepened rapidly in the vicinity of the mean Low near Nova Scotia. Each was accompanied by gale winds and heavy, widespread rain and snow. Several of these cyclones recurved northwestward into eastern Canada and Hudson Bay, instead of proceeding on the customary track northeastward across the Atlantic. This behavior was a reflection of the blocking, strong, easterly flow relative to normal, and the negative trough tilt in eastern Canada.

In the remainder of the United States dry weather prevailed, with less than half of normal precipitation in most of the Mid-West. This was the driest February on record at Cincinnati, Ohio, Madison, Wis., Waterloo, Iowa, Escanaba, Mich., and Minneapolis, Minn. Dry weather in this area was associated with stronger than normal northwesterly flow at sea level and 700-mb., relatively weak cyclonic and frontal activity, and frequent passage of migratory anticyclones (Chart IX).

4. EVOLUTION WITHIN THE MONTH

A. CIRCULATION

In order to illustrate some of the more interesting and extreme circulation states which existed during February 1958, five selected 5-day mean 700-mb. charts have been reproduced as figure 9. The first of these charts is for the period February 1–5, when the 700-mb. zonal index reached its low point of the year (fig. 2). Principal features are the deep troughs and intense centers of negative height departure from normal off the east and west coasts of the United States, and the equally strong positive centers of height anomaly to the north, in blocking ridges over Alaska and Greenland. In all these characteristics figure 9A bears a striking similarity to the 700-mb. chart for January 7–11, 1956, the only 5-day period on record with an even lower zonal index [11].

The second map of the series, for the period February 6–10 (fig. 9B), was selected to illustrate the great intensity attained by the twin blocking Highs over Davis Strait and northwestern Alaska. Positive height anomalies of 840 ft. in the Alaskan High were the largest of the winter in that area; but the positive anomaly of 1150 ft. in Davis Strait was actually exceeded during several periods in January [4] (and also from February 4 to 8).

The third map of the series, for February 15–19, (fig. 9C) coincides with the period of record high subtropical westerlies and the secondary minimum in the temperate westerlies (fig. 2). It is apparent that the unprecedented strength of the subtropical westerlies was a result of the intensification and elongation of the negative anomalies in the western Atlantic and eastern Pacific. Each of these centers attained its maximum intensity of the winter during this period.

In the first three maps of this series the basic wave pattern over the United States, consisting of ridge over the Rockies and trough along the east coast, persisted virtually unchanged from the pattern which had prevailed throughout the preceding month [4]. On the fourth map, however, for the period February 22–26 (fig. 9D), a new mean trough is apparent in the Southern Plains. This trough developed in response to the increasing wavelength between a retrograding trough in the eastern Pacific and a progressive trough in the western Atlantic. Figure 9D also illustrates the only period during the month with a high-index circulation (fig. 2), as blocking weakened and retreated to very high latitudes. Despite its above normal zonal index, figure 9D still exhibits a split jet stream over North America.

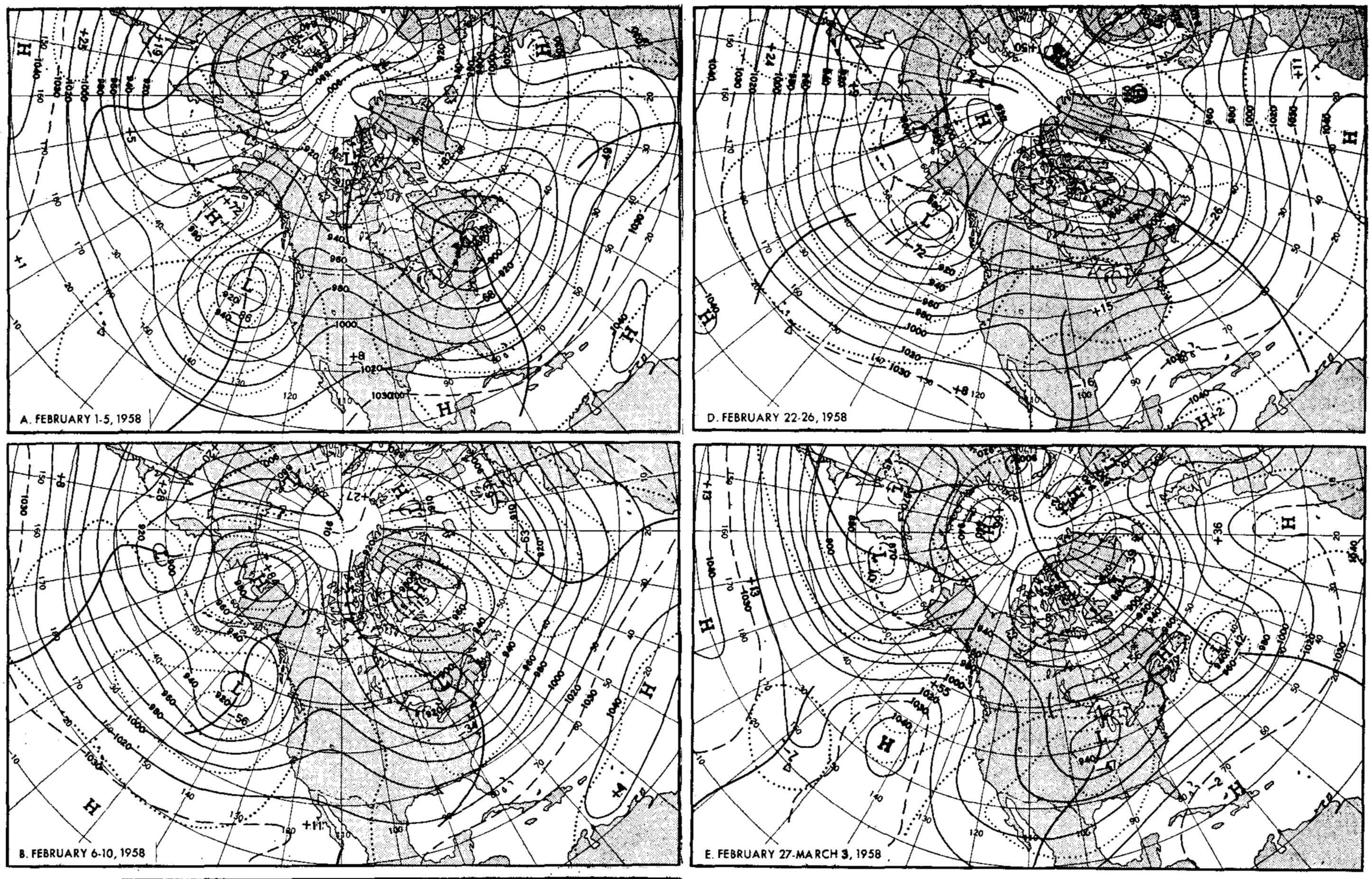
The final map in the series, for the period February 27 to March 3 (fig. 9E), is completely out of phase with the persistent wave pattern exhibited on the monthly mean charts for January and February, as well as on the first three maps of figure 9. This reversal in circulation was effected by marked deepening of the new trough in central United States at the same time that there developed a strong ridge in the eastern Pacific and a weak ridge in the western Atlantic.

B. WEATHER

The transition of weather during the month is conveniently illustrated by figure 10, giving the departure from normal of surface temperature for five successive weeks as published in the *Weekly Weather and Crop Bulletin*. Figure 10A, showing the mean temperature for the week ending February 2, strongly resembles the temperature anomaly pattern for the months of December 1957 and January 1958, with below normal temperatures in the Southeast and above normal in the remainder of the country.

Marked cooling occurred by the second map of the series (fig. 10B) in nearly all areas east of the Continental Divide. Temperatures averaged below normal in parts of the Northern Plains for the first week this winter, as successive cold outbreaks were induced by intensification of the blocking High over Alaska shown in figure 9B.

The intensity and extent of the cold air in the United States reached their peak during the third week of the series (fig. 10C). Below normal temperatures prevailed from the Continental Divide to the Atlantic Coast, with maximum departures of 21 F.° in parts of the Mississippi Valley. In northern New England temperatures averaged below normal for the first time this winter. The cold wave was most severe on the mornings of the 16th and 17th, when dozens of cities in the eastern half of the United States broke records of long standing for daily minimum temperatures. A low of $-23°$ at Mount Mitchell in North Carolina on the 17th was the lowest temperature ever recorded in that State. The cold was



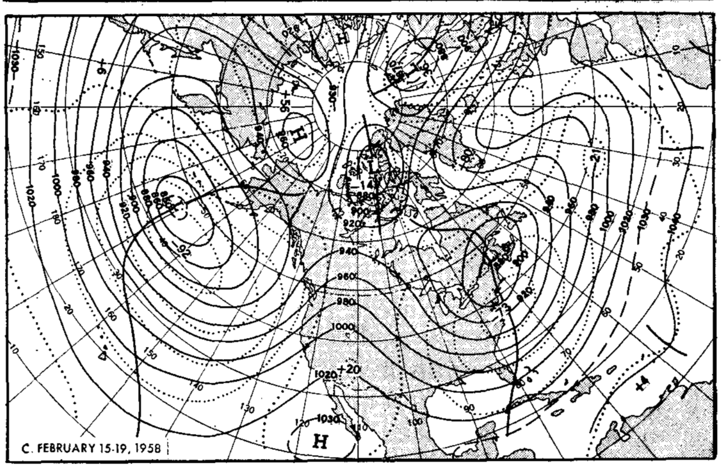
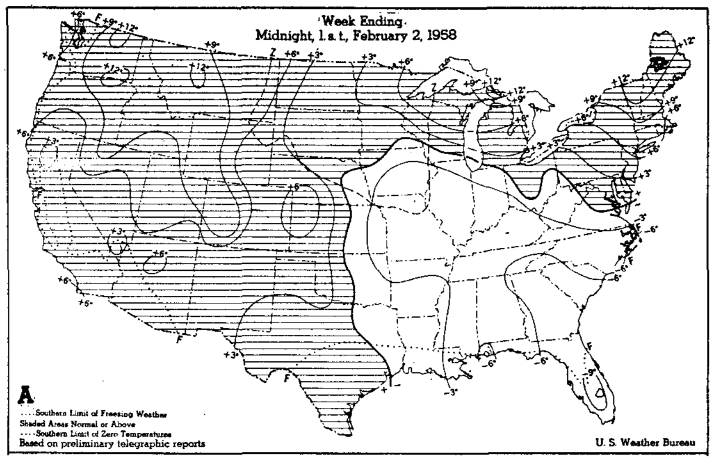
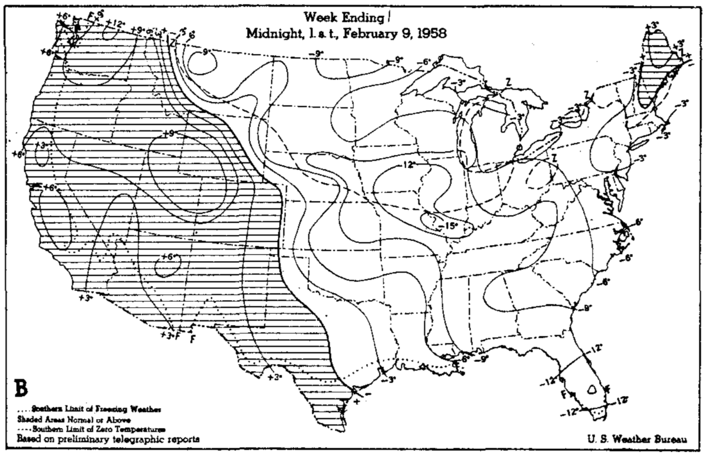


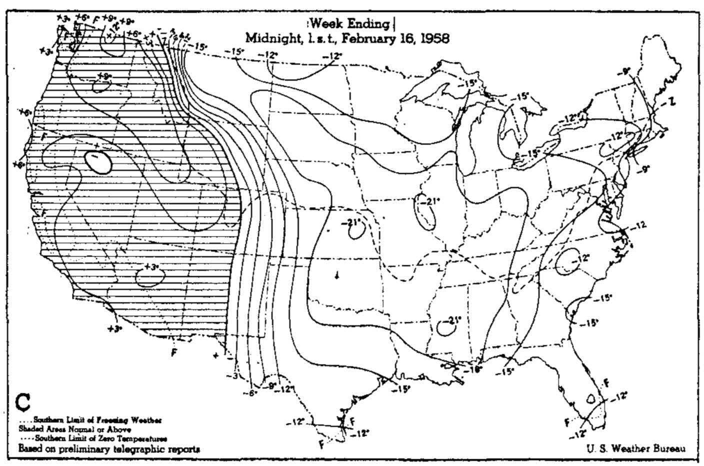
FIGURE 9.—Five-day mean 700-mb. contours (solid) and height departures from normal (dotted) (both in tens of feet) for selected periods in February 1958. Map A illustrates the lowest zonal index of the year, B the most extensive blocking of the month, and C the fastest subtropical westerlies ever observed. Map D illustrates temporary high index and development of new trough in central United States, which subsequently deepened to intense vortex shown in map E.

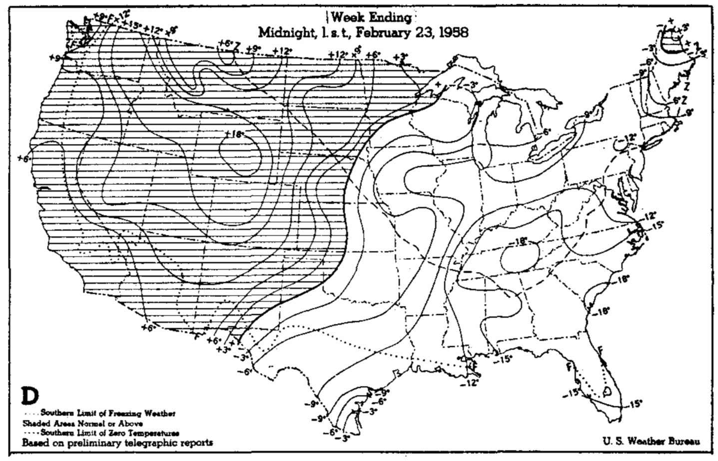
accompanied by history-making snows along the Gulf and Atlantic coasts. On the morning of the 13th Tallahassee, Fla., measured 2.8 in. of snow, the greatest accumulation there since records began in 1895. Another storm on the 16th and 17th set new 24-hour snowfall records at Blue Hill, Mass. (22.2 in.) and Schenectady, N. Y., while Burlington, Vt. and Reading, Pa. reported their deepest snowcover on record.

By the fourth week of the series (fig. 10D) considerable warming occurred in the Great Plains and across the northern border, but the Southeast remained cold. At Corinth, Miss. temperatures averaged lower than for any previous week on record, while new low temperature marks were set for the 18th, 19th, and 20th at numerous cities in the South and East. On the other hand, many high temperature records were broken at western cities during each day of the week, and weekly temperatures averaged as much as 18 F.° above normal in Wyoming. Absolute maxima for any day in February were reported at Boise and Pocatello, Idaho on the 22d (67° F.) and at Sioux Falls, S. Dak. on the 23d. Warming in the West was associated with intensification of the upper-level









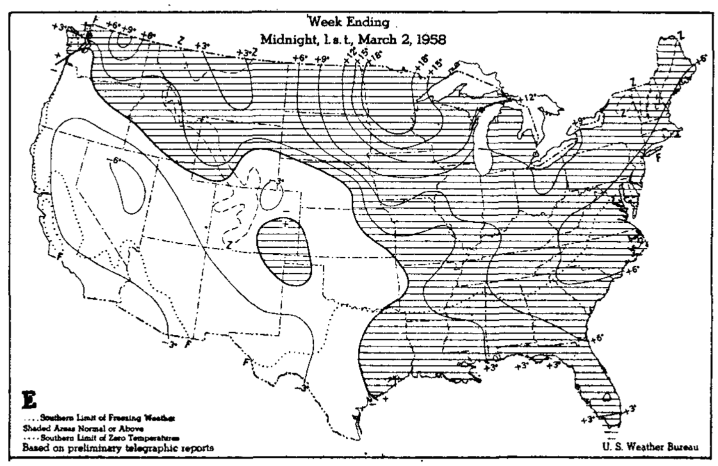


FIGURE 10.—Departures of average surface temperature from normal (F.°) for each week of February 1958. Map A represents persistence of the January pattern. The below normal temperatures expanded in area during the second week, attained maximum intensity during the third week, and contracted again in the fourth week. The final map marks a complete reversal in pattern, with above normal temperature in the Southeast for the first time this year. (From *Weekly Weather and Crop Bulletin, National Summary*, vol. XLV, nos. 5–10, Feb. 3, 10, 17, and 24, and Mar. 3, 1958.)

ridge in that area (fig. 9C), followed by flattening and acceleration of the westerlies (fig. 9D) during a period of temporary high index (fig. 2).

A complete reversal in temperature pattern occurred by the last week of the series (fig. 10E) as temperatures finally climbed to above normal readings in the Southeast but dropped to below normal in the Southwest. This reversal was accompanied by marked deepening of the new trough which had developed in the central United States (fig. 9E). Intense cyclonic activity in this trough produced the lowest pressure on record at numerous stations in Washington on the 24th, Montana on the 25th, Texas, Oklahoma, and Arkansas on the 26th, and Arkansas, Missouri, and Illinois on the 27th. Sea level pressure in the center of the storm was estimated at 976 mb. in Missouri on February 27 (Chart X). The greatest amounts of precipitation ever observed in a 24-hour period were reported from Lincoln, Nebr. and Huron, S. Dak. on the 27th.

Tornadoes in Mississippi, floods in Texas and the Northeast, and blizzard conditions in the Great Plains were additional highlights of the week. This storminess was preceded by abnormal warmth, with numerous cities in the Plains and Mid-West setting new daily maximum records on the 24th, 25th, and 26th, while new absolute highs for February were reported in the Dakotas on the 25th (68° F. at Bismarck, N. Dak.). For further details about the intense cyclone in the central United States, the reader is referred to an adjoining article by Shellum and Tait.

To summarize the transition within the month, it may be noted that intensification of the blocking at the beginning of the month (fig. 9A and B) led to outbreaks of extremely cold air in the eastern two-thirds of the United States around mid-month (fig. 10B and C). As this cold air streamed over the warm waters of the Gulf of Mexico and western Atlantic, conditions were favorable for baroclinic deepening of coastal storms at low latitudes. As a result, both the east coast trough (fig. 9C) and the subtropical westerly index (fig. 2) attained record-breaking proportions shortly after mid-month. Northward motion of the principal centers of action during the next week was accompanied by strengthening of the westerlies at middle latitudes (fig. 9D). With the onset of high index (fig. 2), widespread warming occurred over the United States (fig. 10D and E). The intensity of this warming helped set the stage for record low sea level pressure and baroclinic deepening as a new trough developed in the central United States (fig. 9E) at the end of the month.

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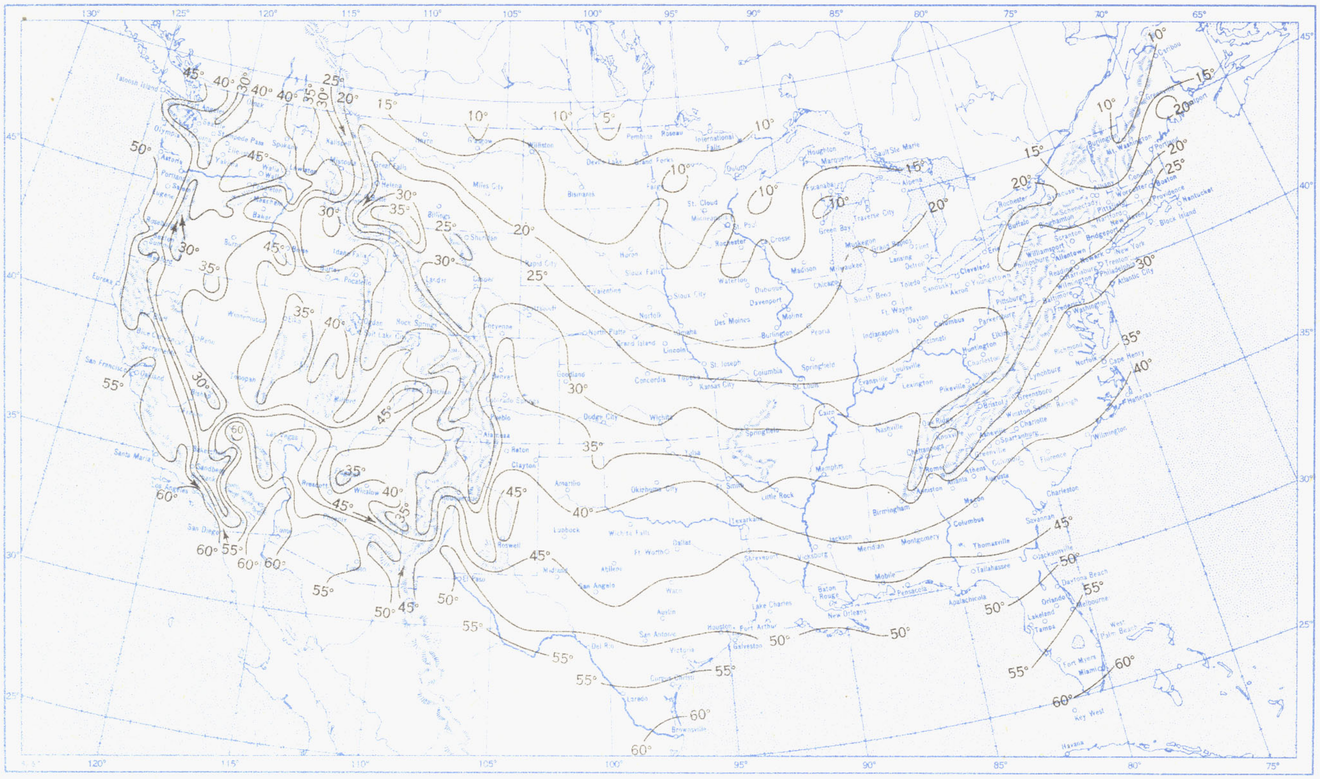
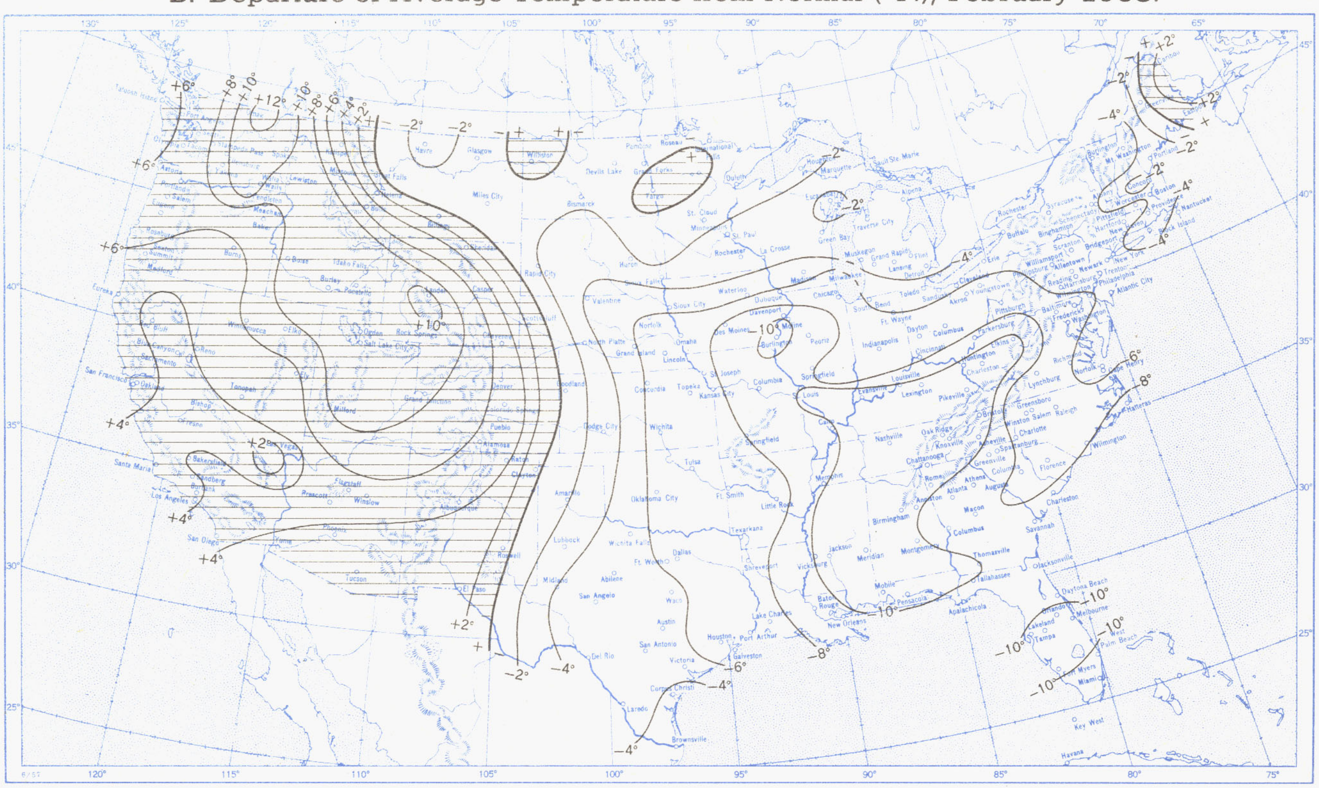
Chart I. A. Average Temperature (°F.) at Surface, February 1958.

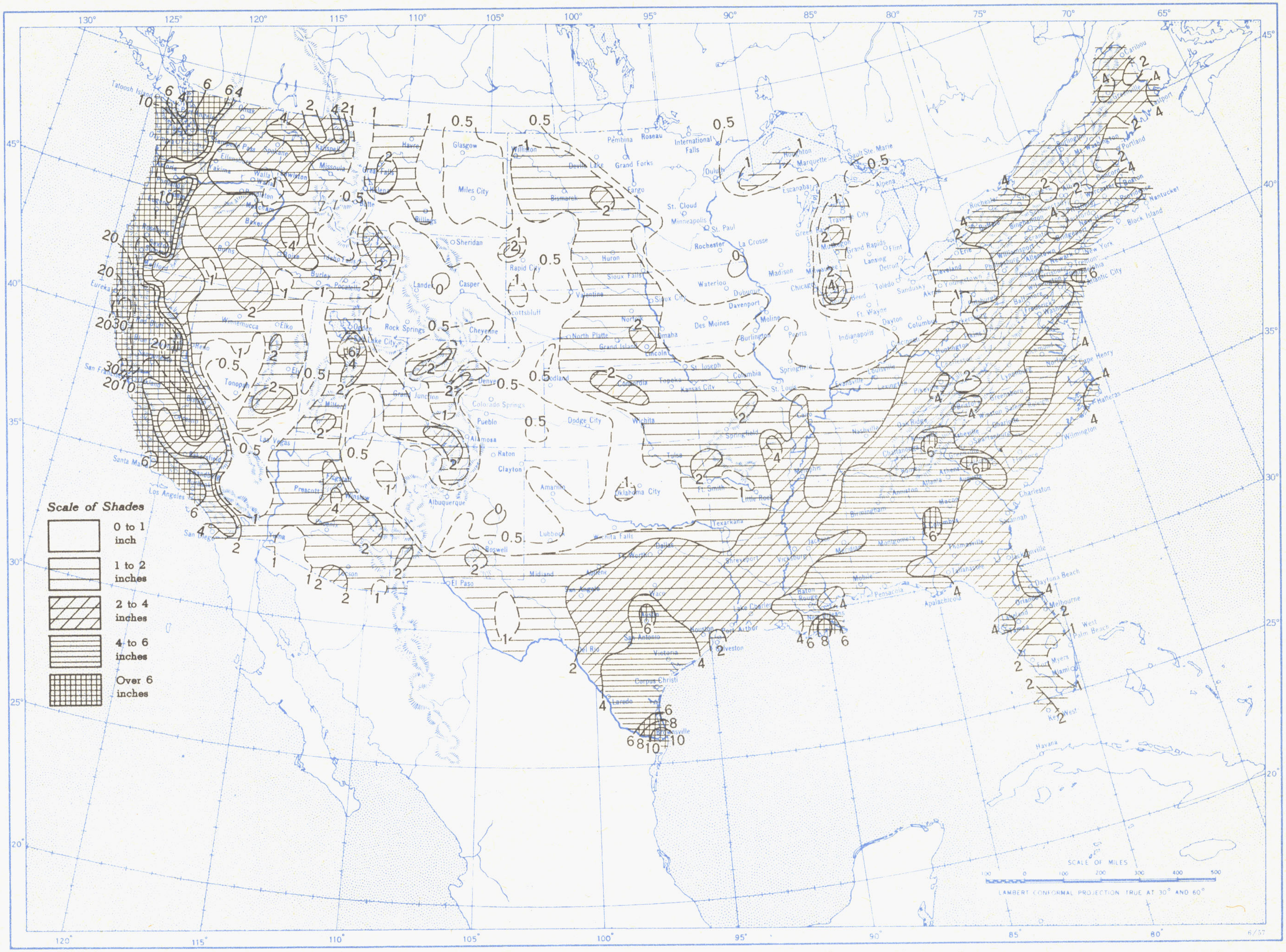


B. Departure of Average Temperature from Normal (°F.), February 1958.



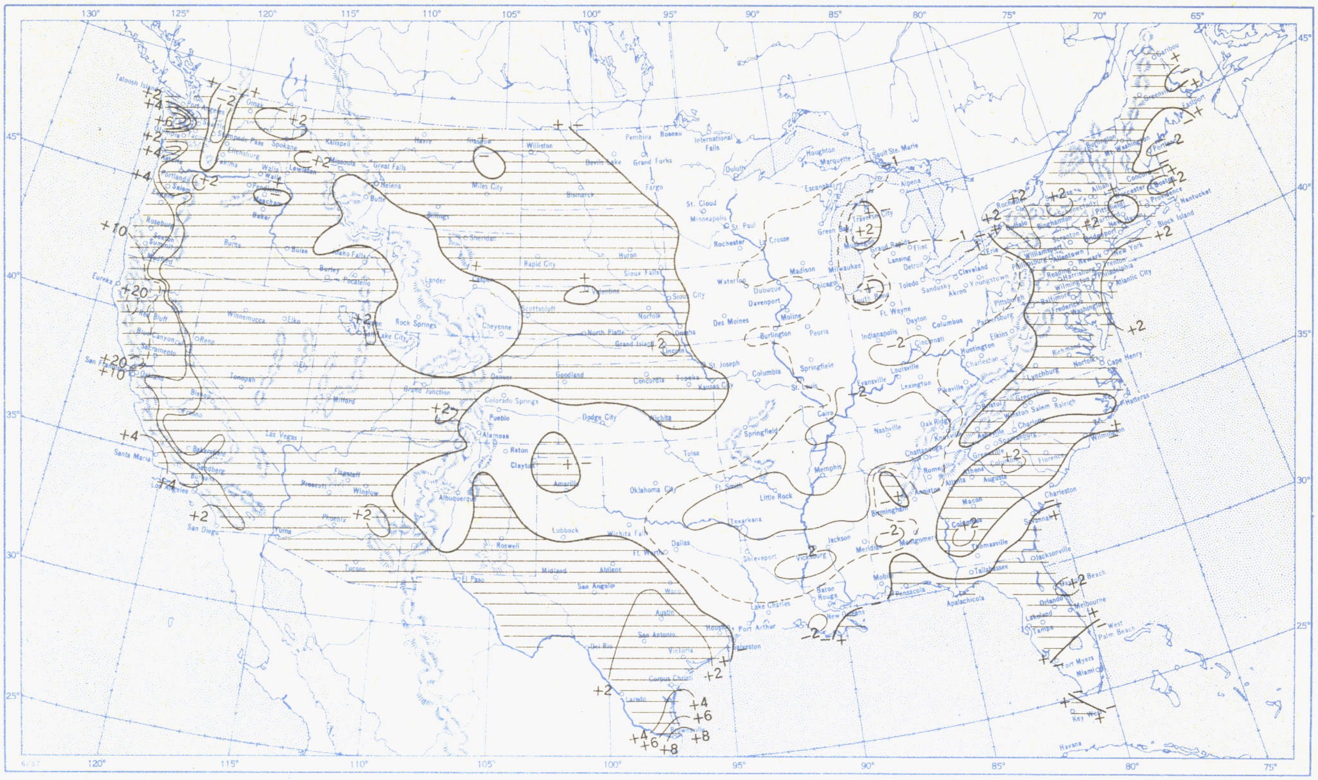
A. Based on reports from over 900 Weather Bureau and cooperative stations. The monthly average is half the sum of the monthly average maximum and monthly average minimum, which are the average of the daily maxima and daily minima, respectively.
B. Departures from normal are based on the 30-yr. normals (1921-50) for Weather Bureau stations and on means of 25 years or more (mostly 1931-55) for cooperative stations.

Chart II. Total Precipitation (Inches), February 1958.

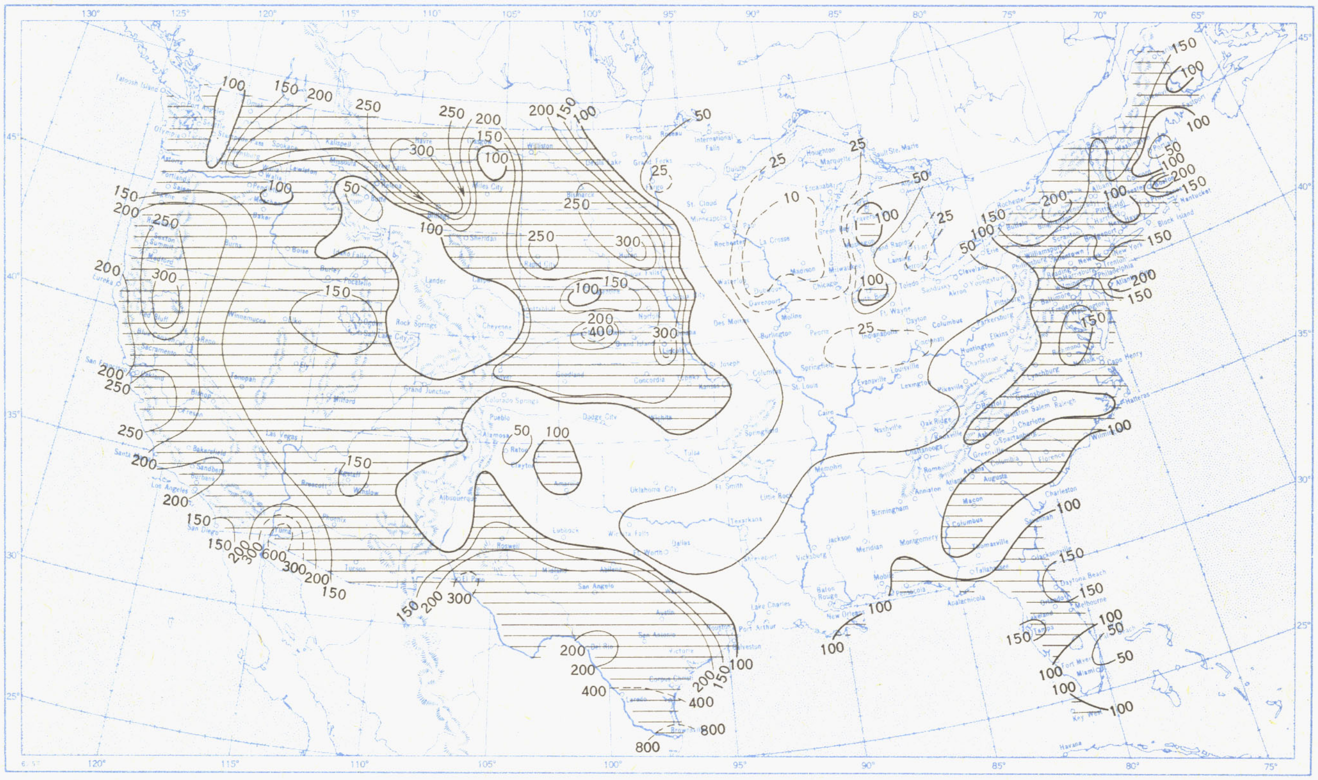


Based on daily precipitation records at about 800 Weather Bureau and cooperative stations.

Chart III. A. Departure of Precipitation from Normal (Inches), February 1958.

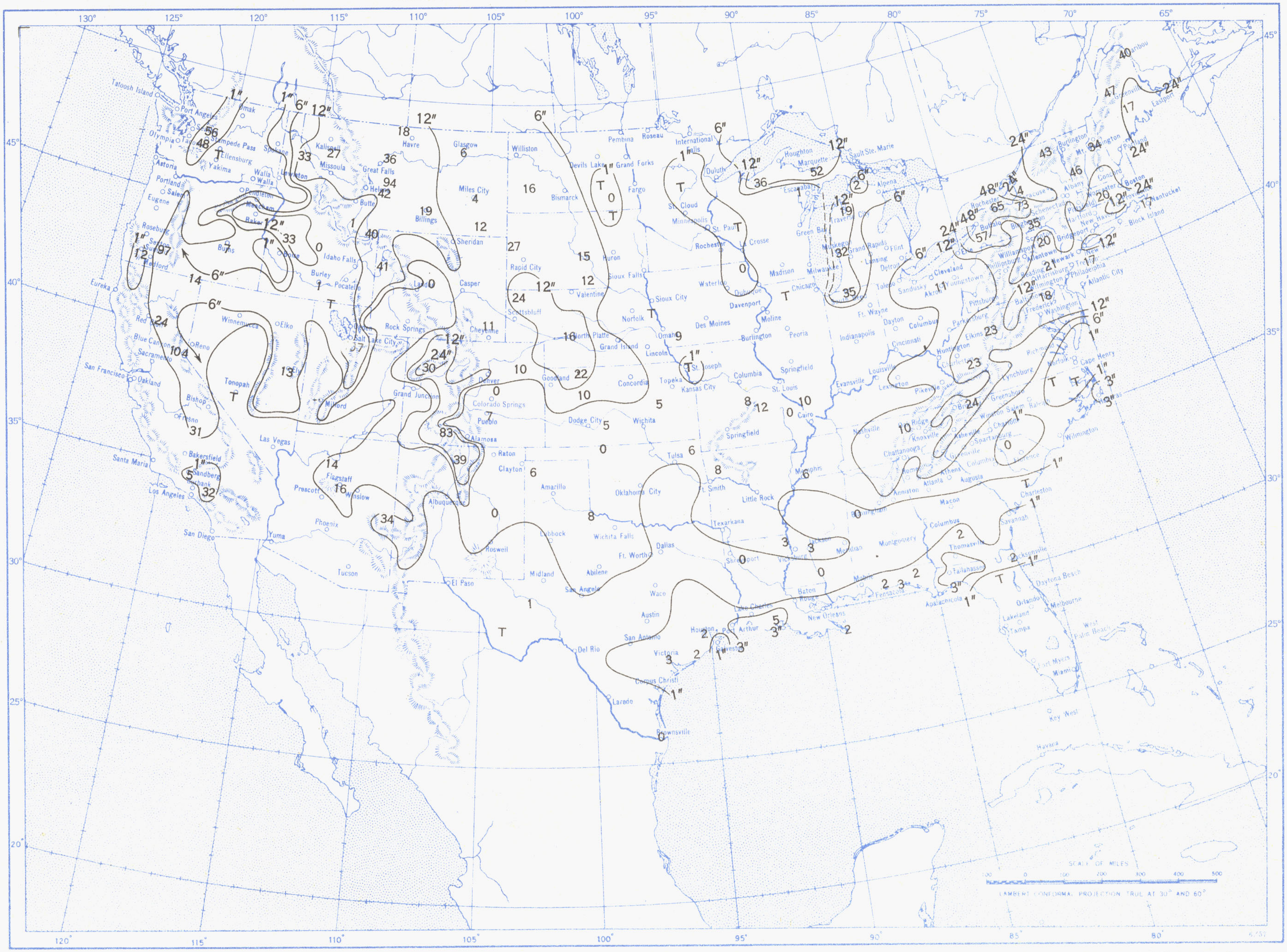


B. Percentage of Normal Precipitation, February 1958.



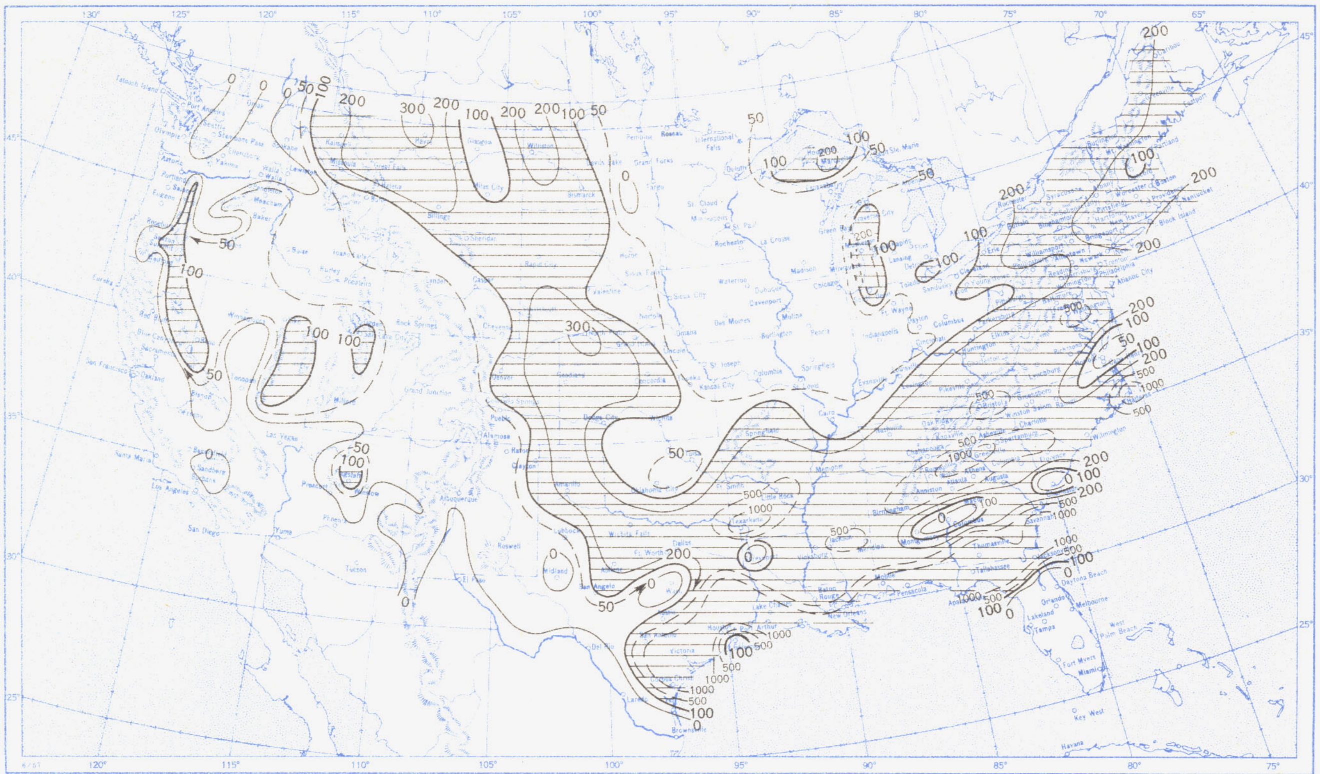
Normal monthly precipitation amounts are computed from the records for 1921-50 for Weather Bureau stations and from records of 25 years or more (mostly 1931-55) for cooperative stations.

Chart IV. Total Snowfall (Inches), February 1958.

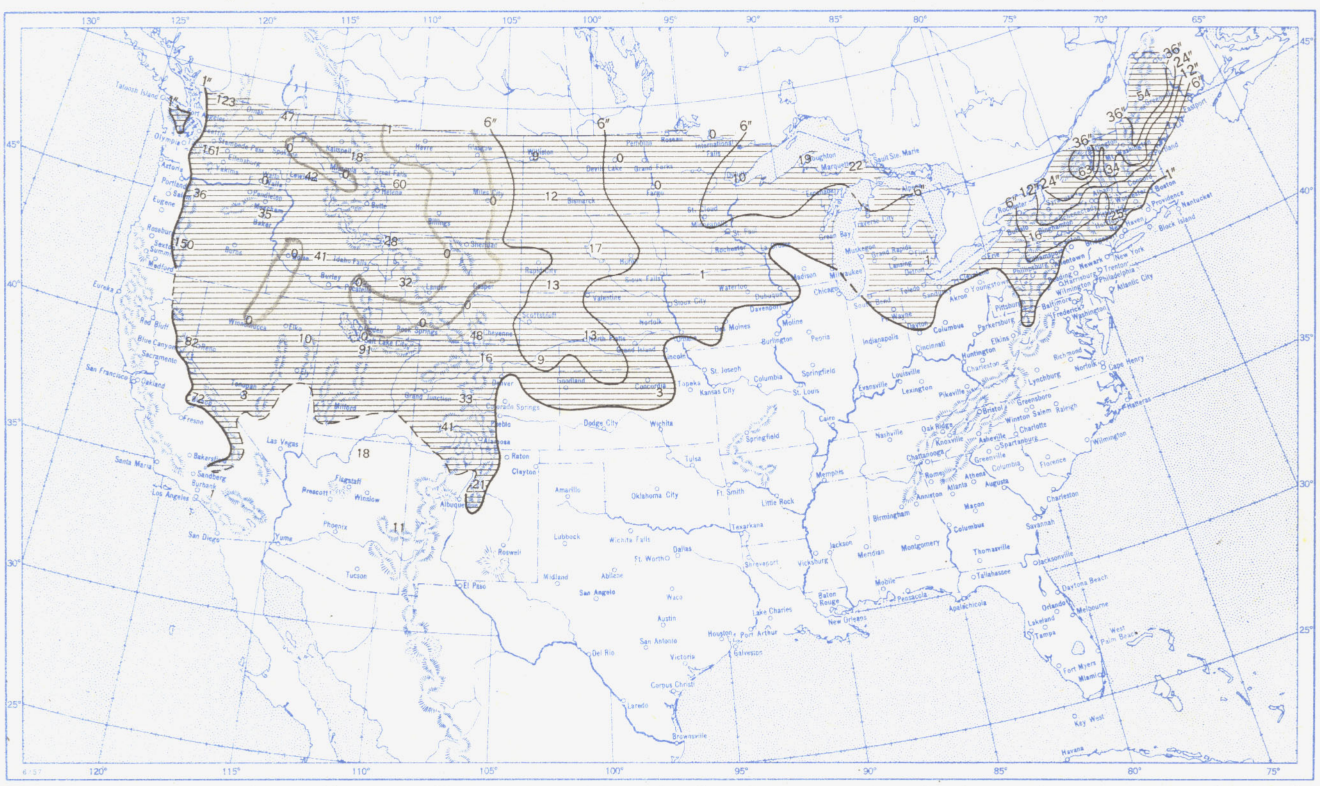


This is the total of unmelted snowfall recorded during the month at Weather Bureau and cooperative stations. This chart and Chart V are published only for the months of November through April although of course there is some snow at higher elevations, particularly in the far West, earlier and later in the year.

Chart V. A. Percentage of Normal Snowfall, February 1958.

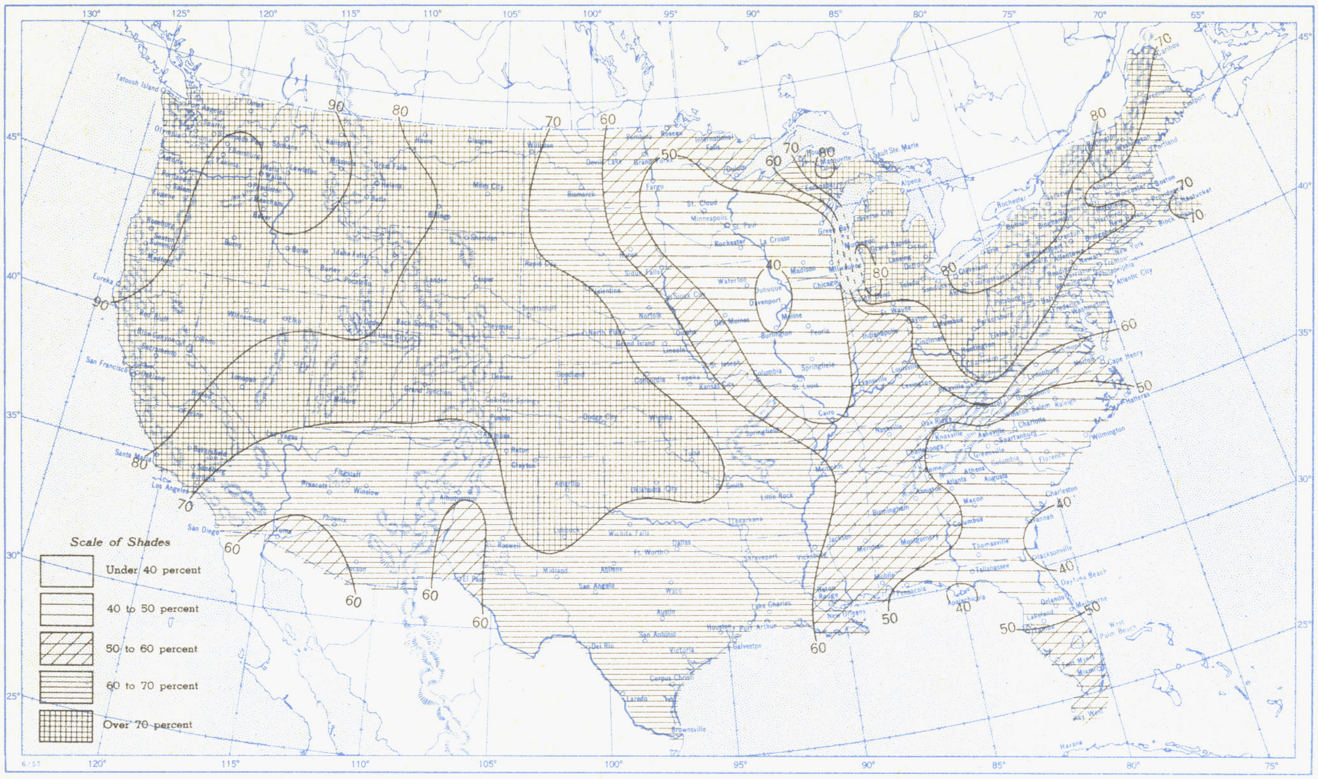


B. Depth of Snow on Ground (Inches), 7:00 a. m. E. S. T., ~~February 24~~ MAR 3, 1958.

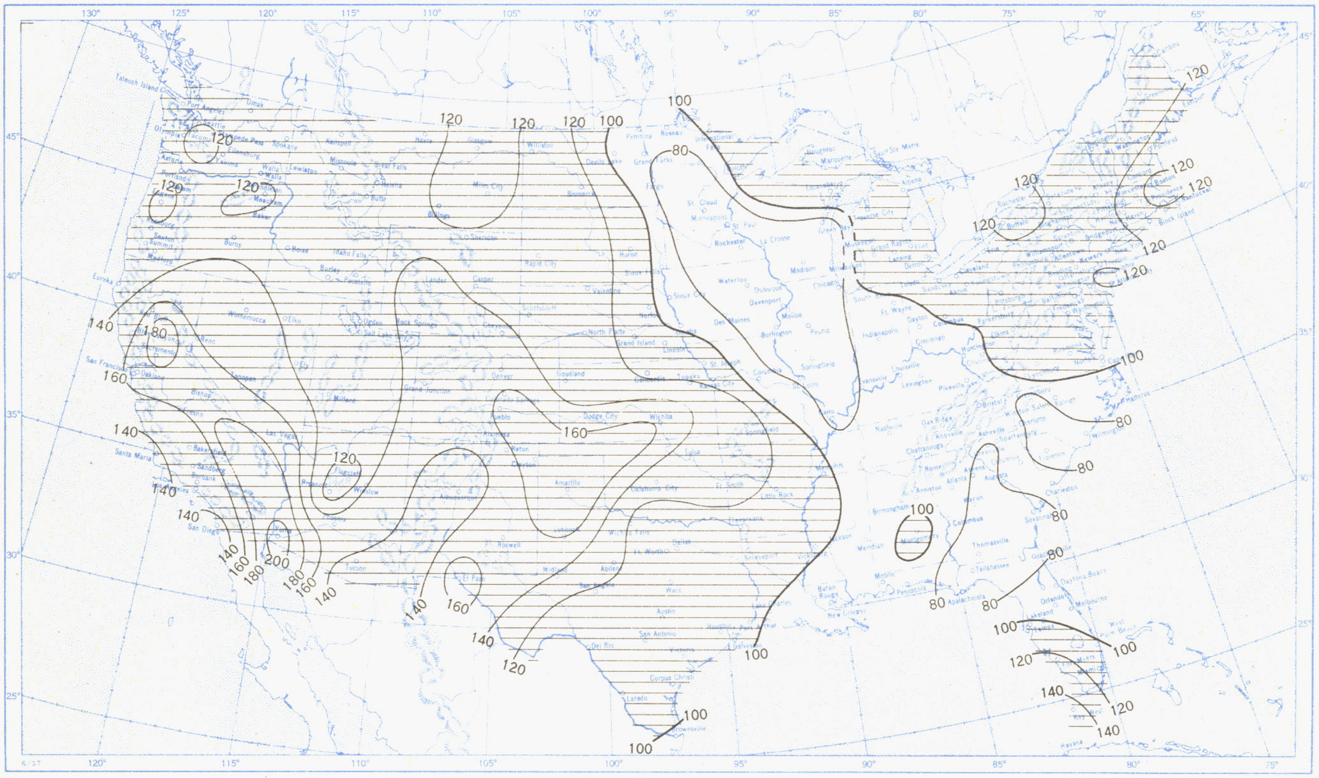


A. Amount of normal monthly snowfall is computed for Weather Bureau stations having at least 10 years of record.
B. Shows depth currently on ground at 7:00 a. m. E. S. T., of the Monday nearest the end of the month. It is based on reports from Weather Bureau and cooperative stations. Dashed line shows greatest southern extent of snowcover during month.

Chart VI. A. Percentage of Sky Cover Between Sunrise and Sunset, February 1958.

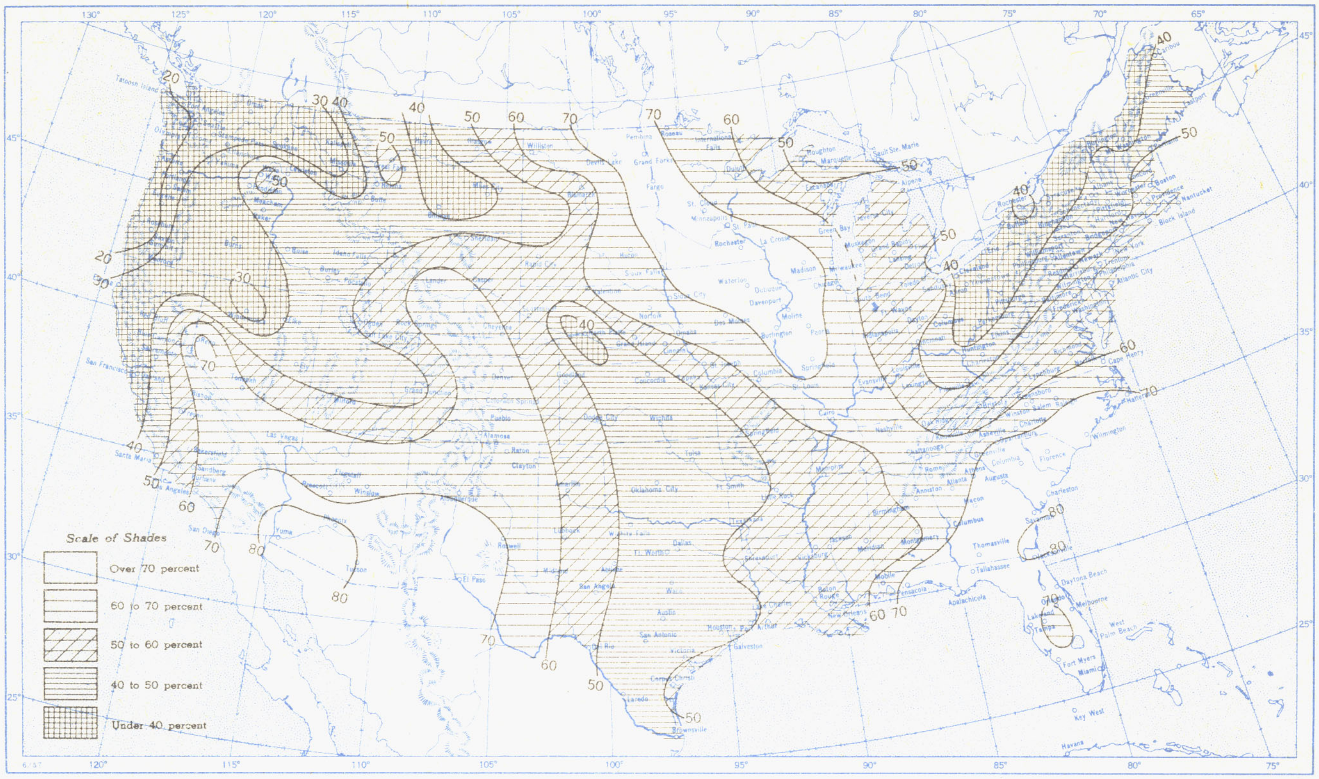


B. Percentage of Normal Sky Cover Between Sunrise and Sunset, February 1958.

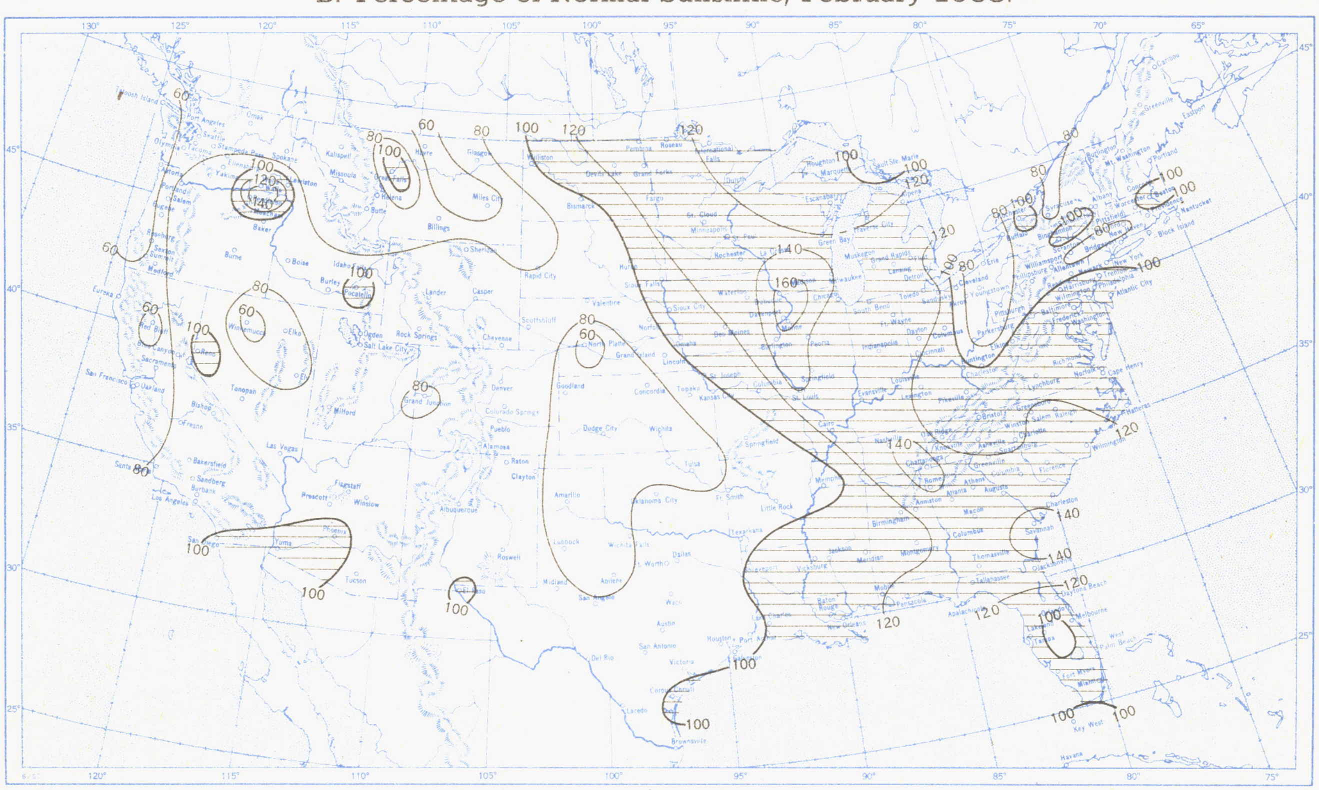


A. In addition to cloudiness, sky cover includes obscuration of the sky by fog, smoke, snow, etc. Chart based on visual observations made hourly at Weather Bureau stations and averaged over the month. B. Computations of normal amount of sky cover are made for stations having at least 10 years of record.

Chart VII. A. Percentage of Possible Sunshine, February 1958.



B. Percentage of Normal Sunshine, February 1958.



A. Computed from total number of hours of observed sunshine in relation to total number of possible hours of sunshine during month. B. Normals are computed for stations having at least 10 years of record.

Chart VIII. Average Daily Values of Solar Radiation, Direct + Diffuse, February 1958. Inset: Percentage of Mean Daily Solar Radiation, February 1958. (Mean based on period 1951-55.)

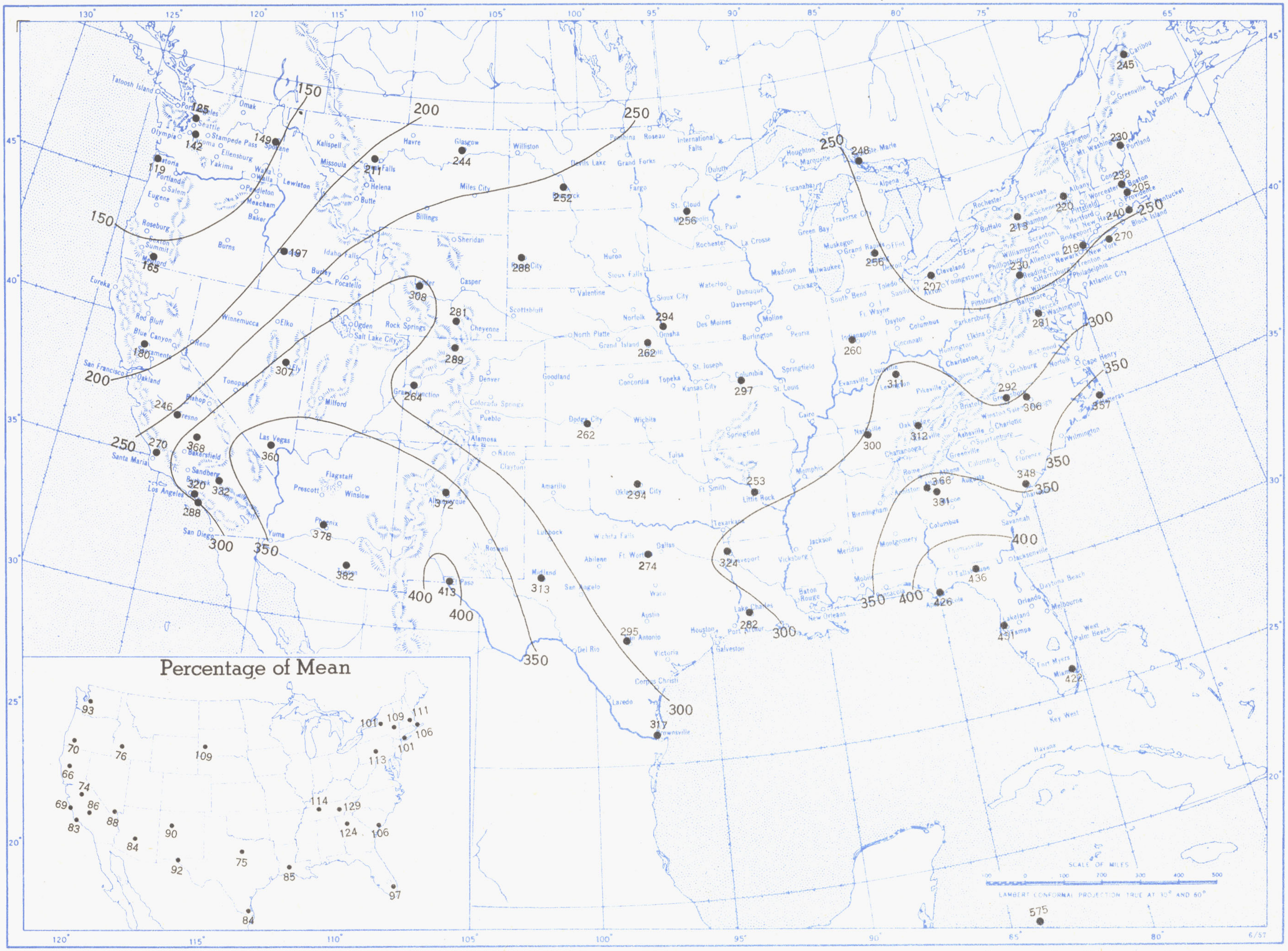
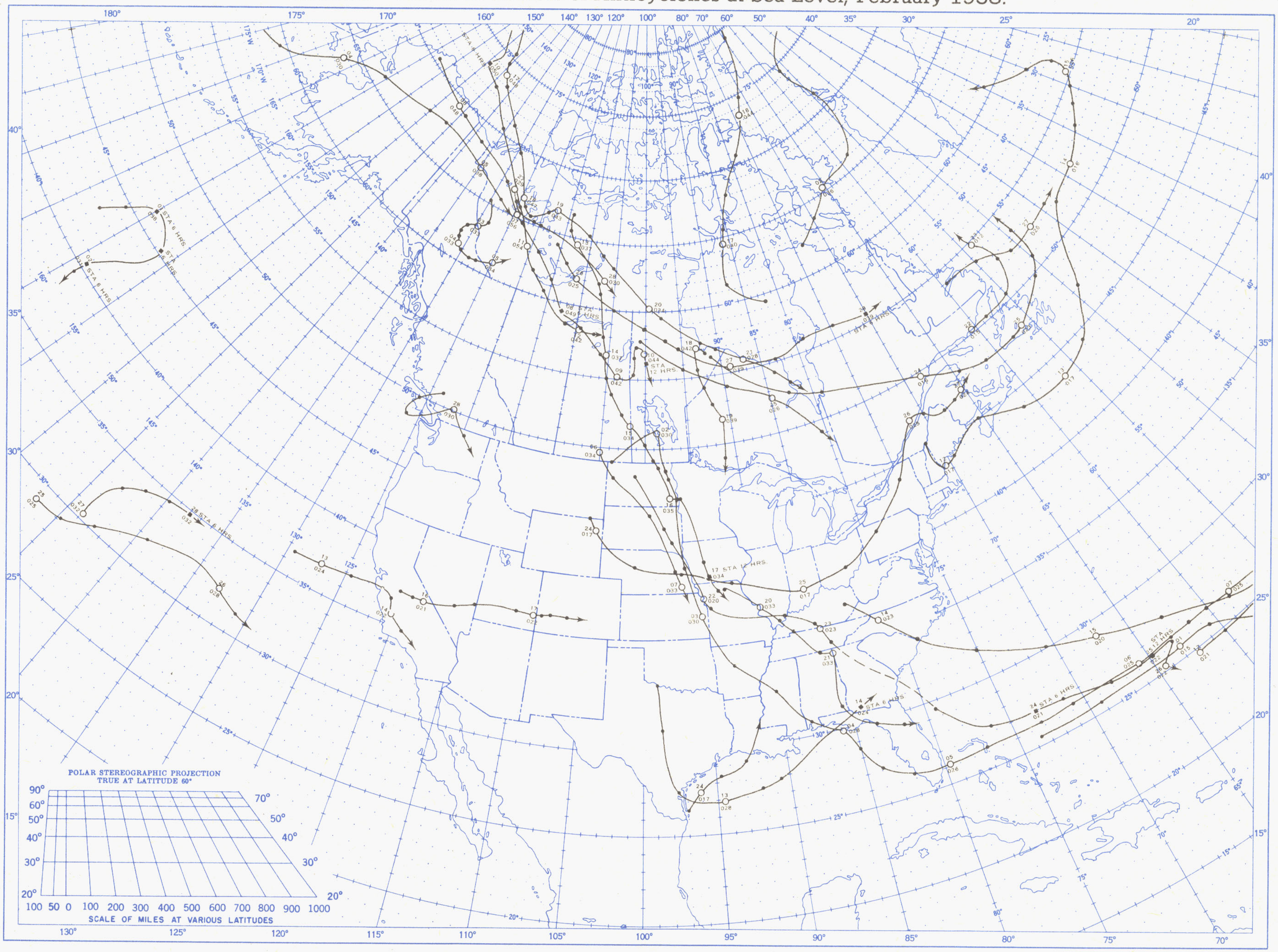


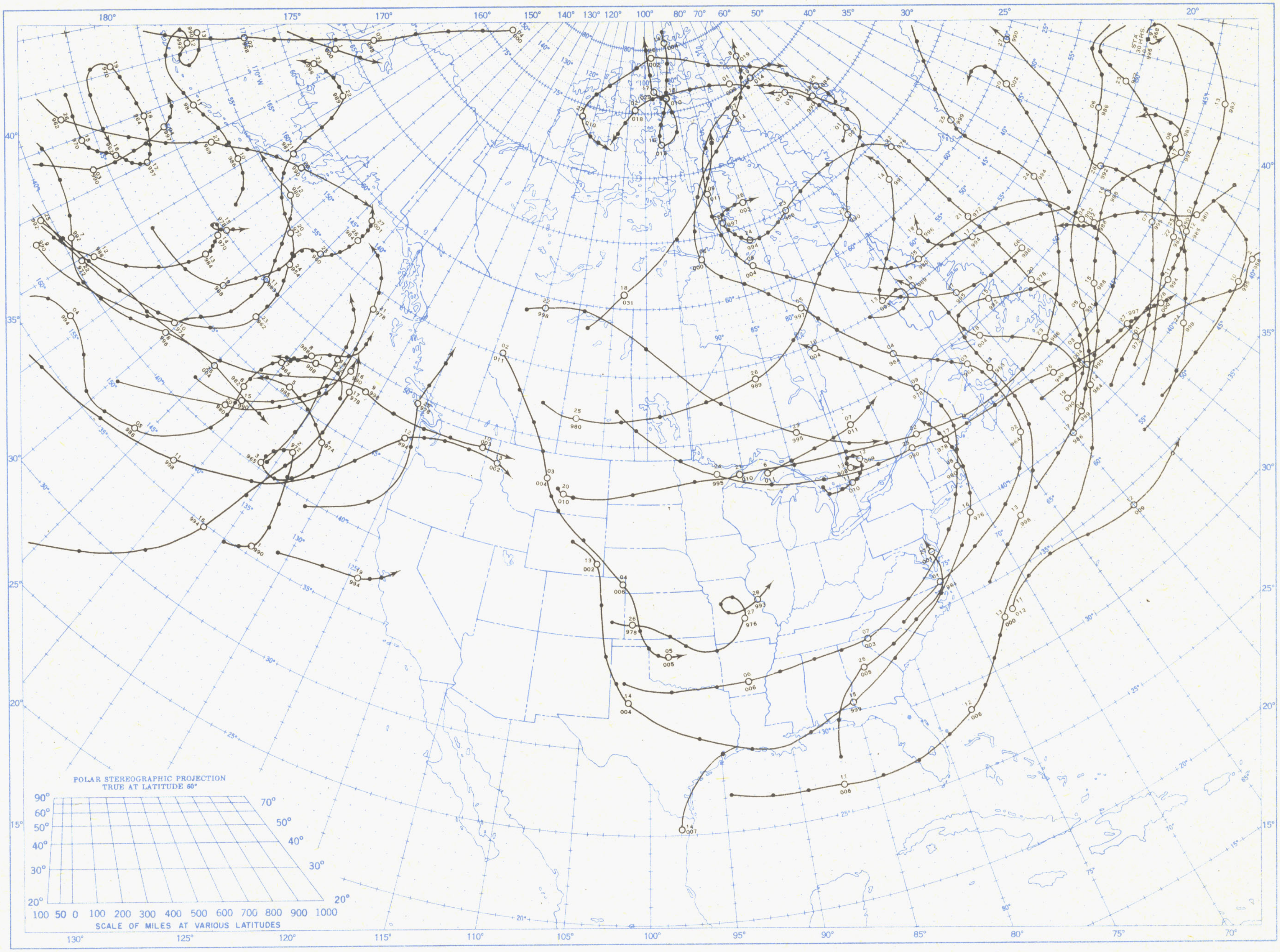
Chart shows mean daily solar radiation, direct + diffuse, received on a horizontal surface in langleys (1 langley = $1 \text{ gm. cal. cm.}^{-2}$). Basic data for isolines are shown on chart. Further estimates are obtained from supplementary data for which limits of accuracy are wider than for those data shown. The inset shows the percentage of the mean based on the period 1951-55.

Chart IX. Tracks of Centers of Anticyclones at Sea Level, February 1958.



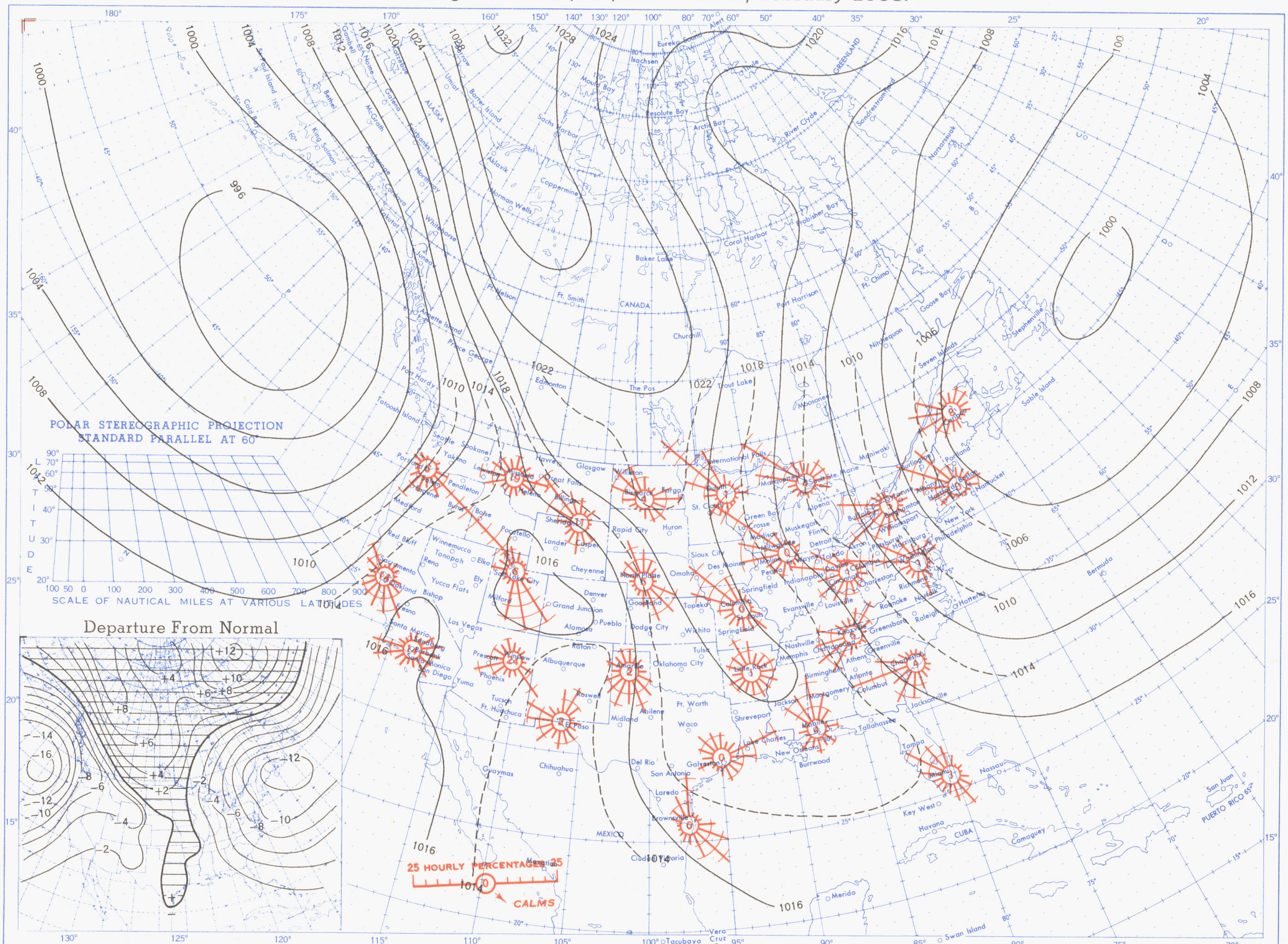
Circle indicates position of center at 7:00 a. m. E. S. T. Figure above circle indicates date, figure below, pressure to nearest millibar. Dots indicate intervening 6-hourly positions. Squares indicate position of stationary center for period shown. Dashed line in track indicates reformation at new position. Only those centers which could be identified for 24 hours or more are included.

Chart X. Tracks of Centers of Cyclones at Sea Level, February 1958.



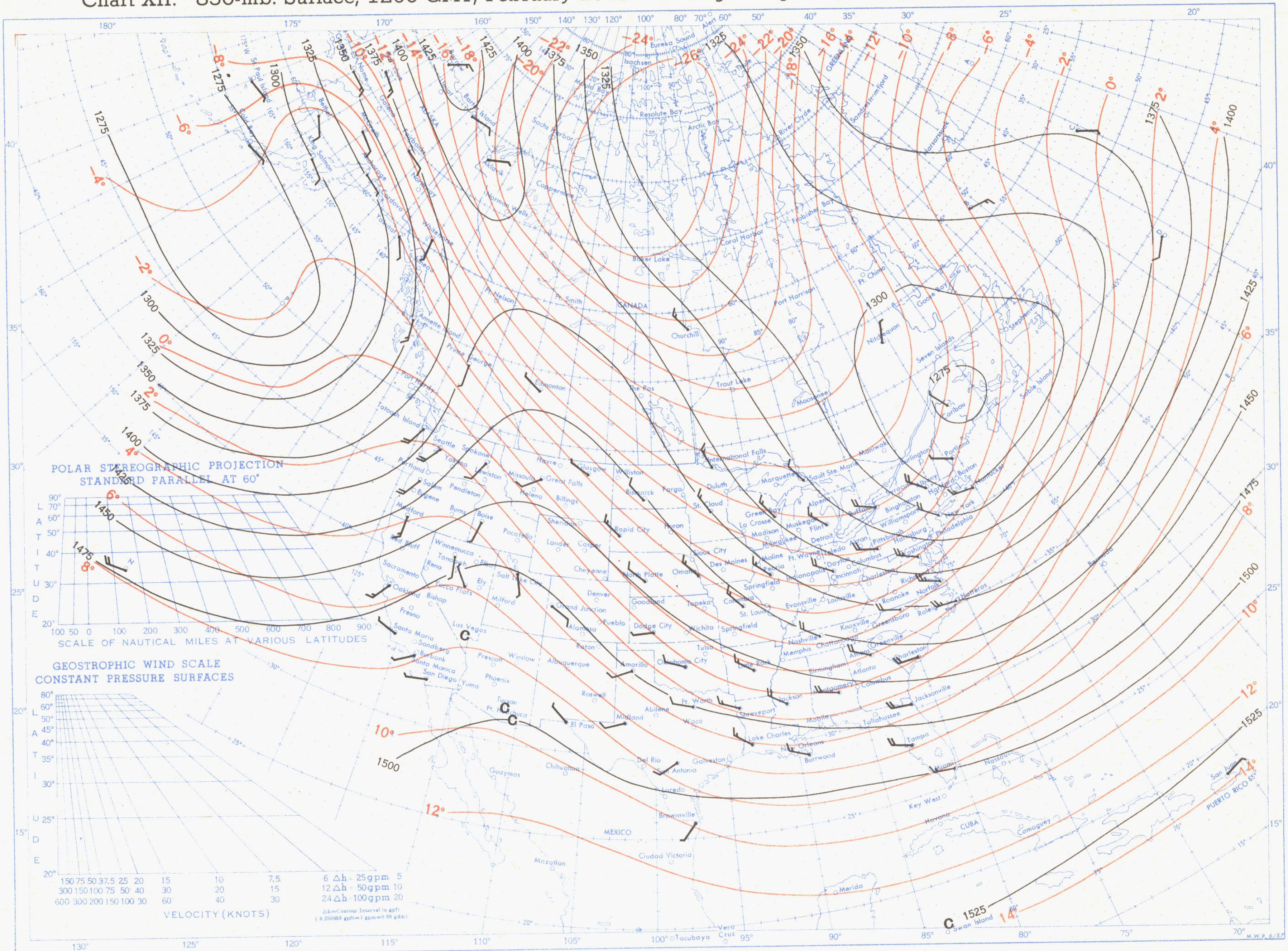
Circle indicates position of center at 7:00 a. m. E. S. T. See Chart IX for explanation of symbols.

Chart XI. Average Sea Level Pressure (mb.) and Surface Windroses, February 1958. Inset: Departure of Average Pressure (mb.) from Normal, February 1958.



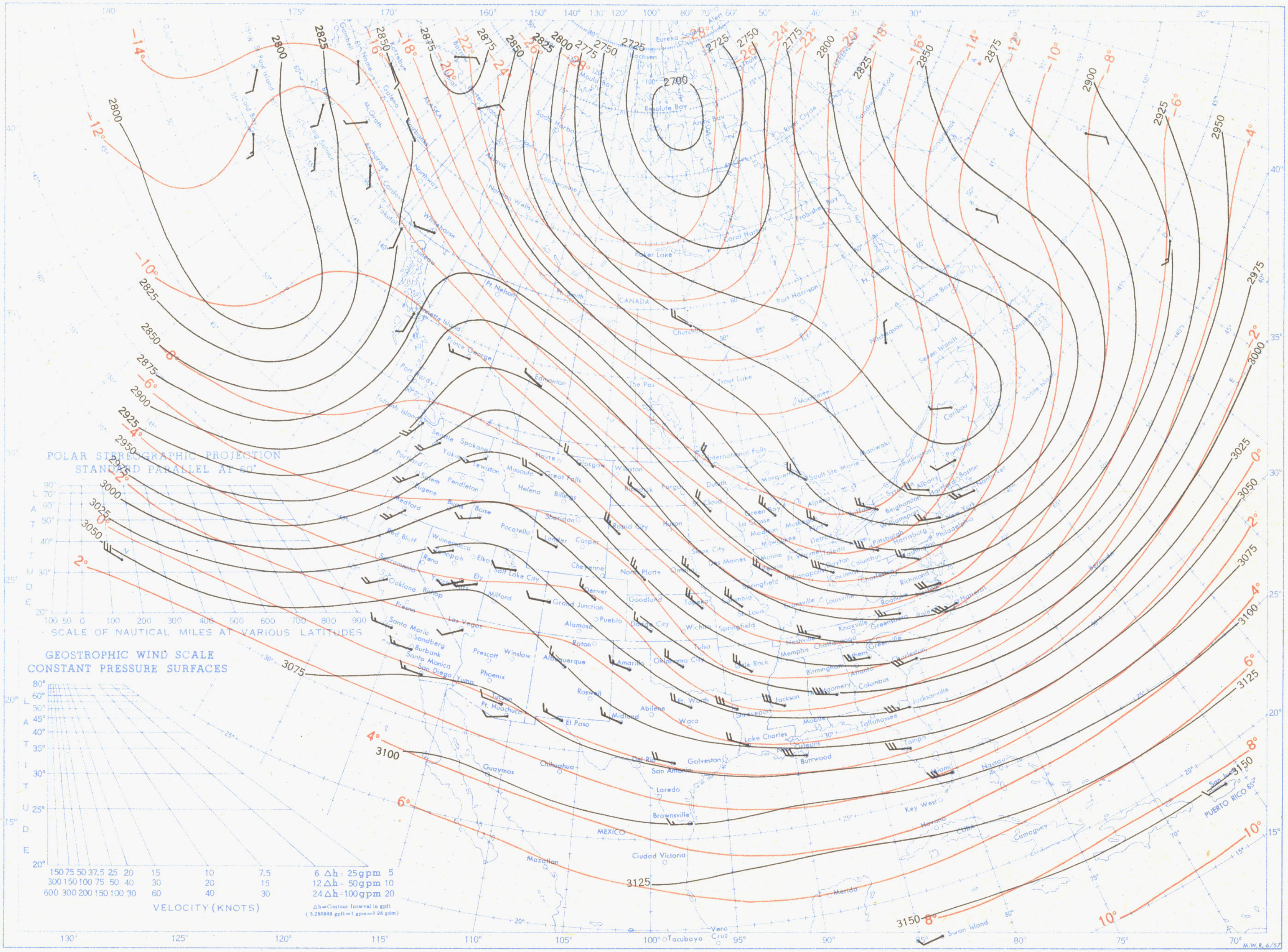
Average sea level pressures are obtained from the averages of the 7:00 a. m. and 7:00 p. m. E. S. T. readings. Windroses show percentage of time wind blew from 16 compass points or was calm during the month. Pressure normals are computed for stations having at least 10 years of record and for 10° intersections in a diamond grid based on readings from the Historical Weather Maps (1899-1939) for the 20 years of most complete data coverage prior to 1940.

Chart XII. 850-mb. Surface, 1200 GMT, February 1958. Average Height and Temperature, and Resultant Winds.



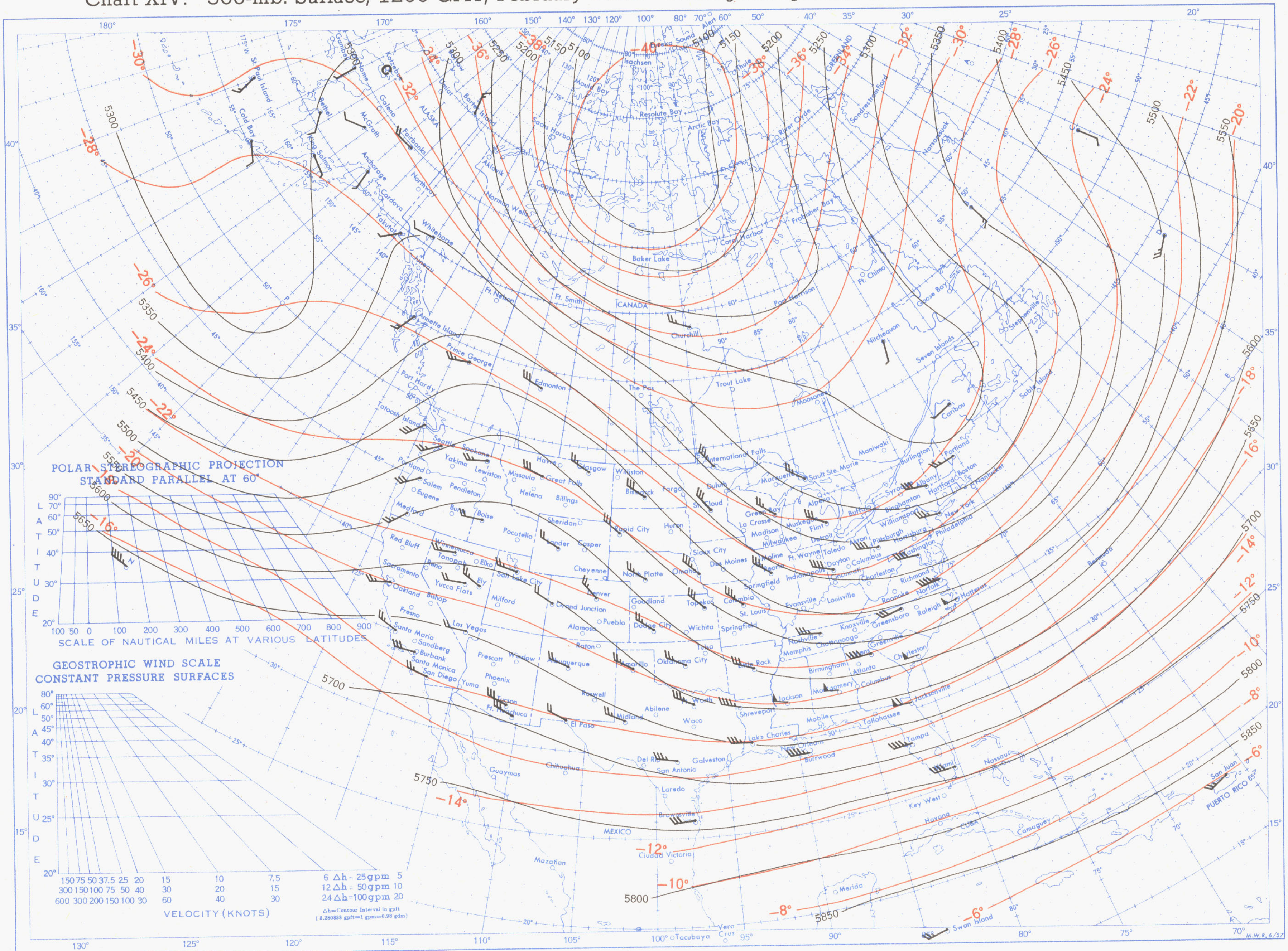
Height in geopotential meters (1 g.p.m. = 0.98 dynamic meters). Temperature in °C. Wind speed in knots; flag represents 50 knots, full feather 10 knots, and half feather 5 knots. All wind data are based on rawin observations.

Chart XIII. 700-mb. Surface, 1200 GMT, February 1958. Average Height and Temperature, and Resultant Winds.



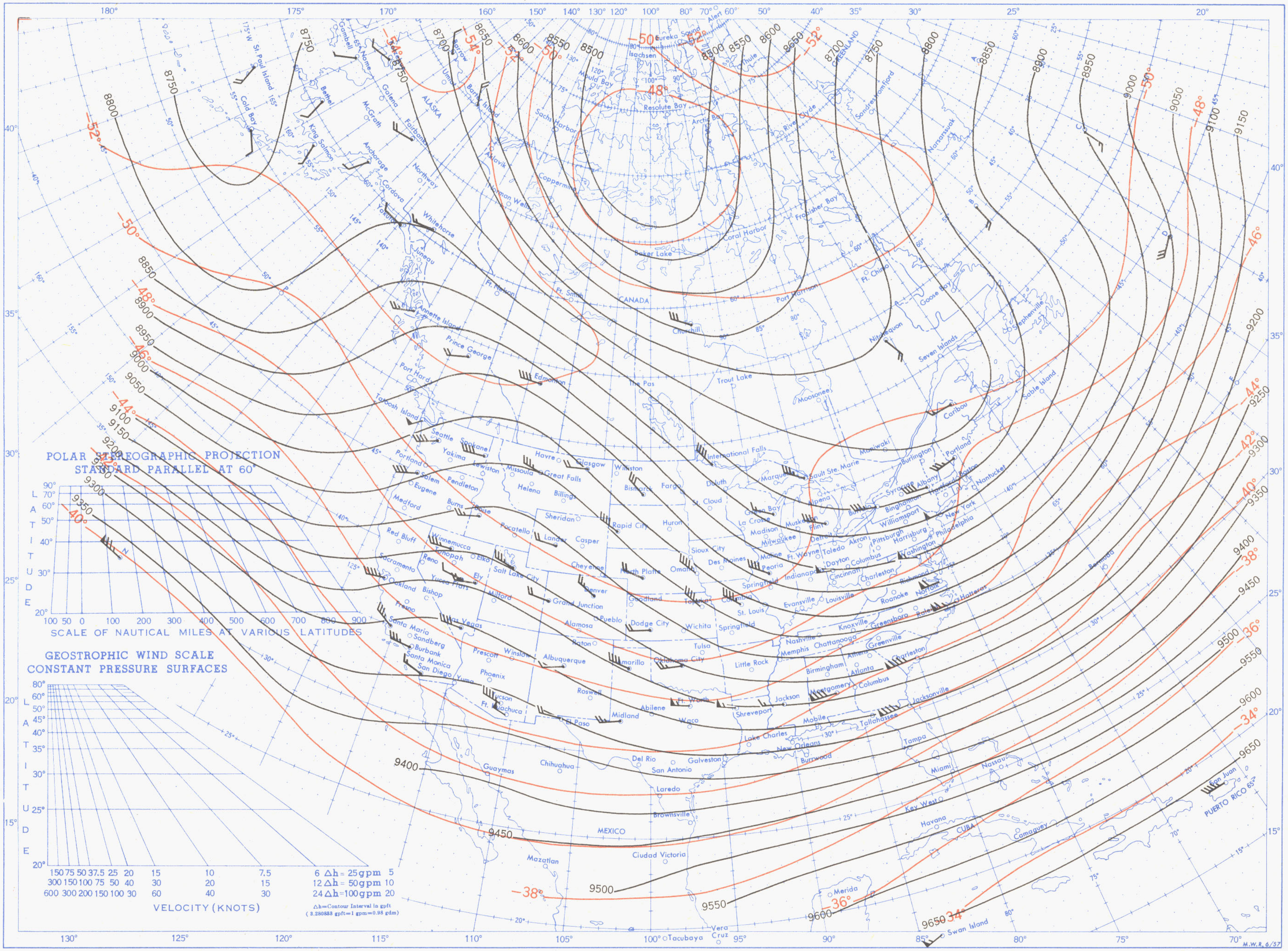
See Chart XII for explanation of map.

Chart XIV. 500-mb. Surface, 1200 GMT, February 1958. Average Height and Temperature, and Resultant Winds.



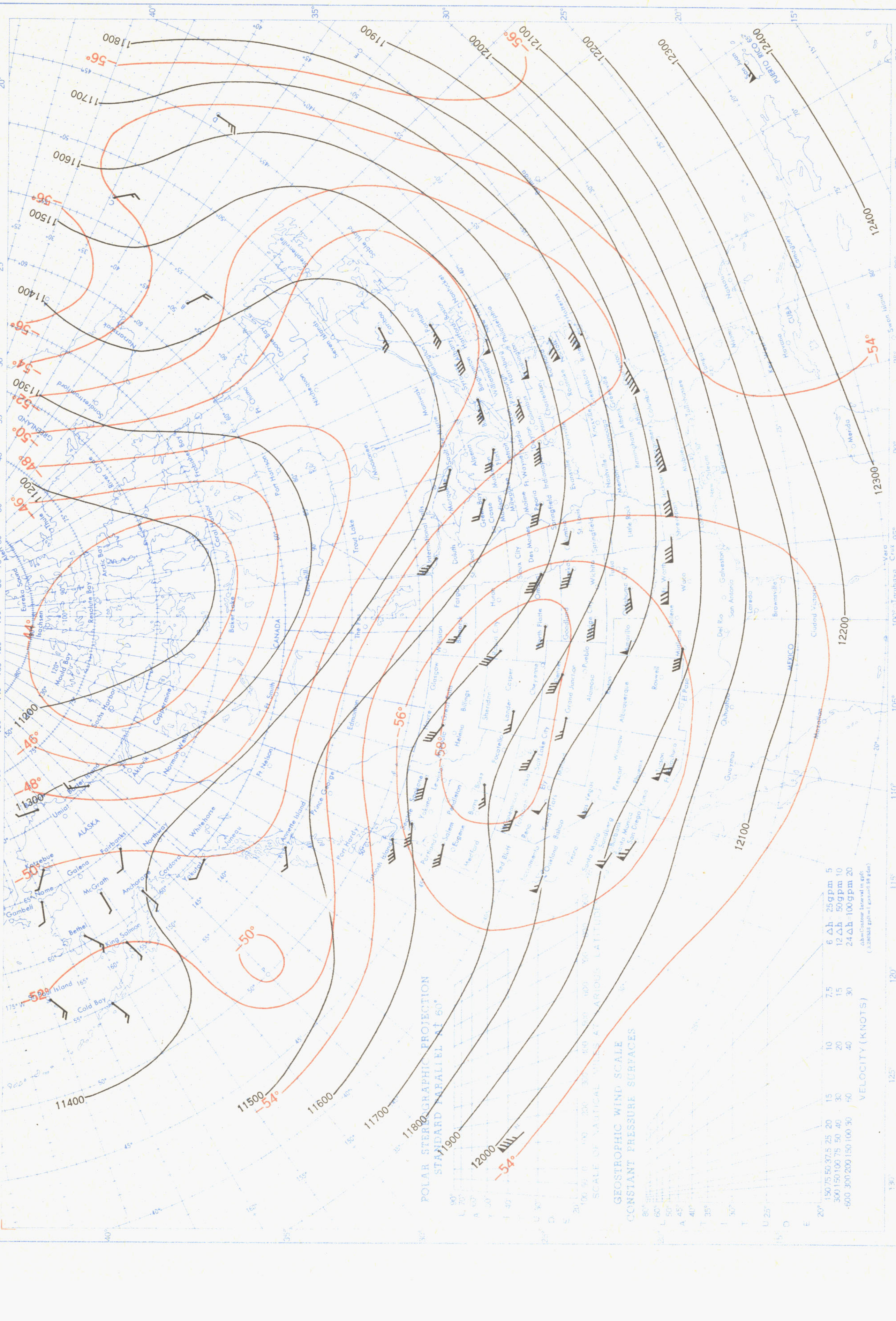
See Chart XII for explanation of map.

Chart XV. 300-mb. Surface, 1200 GMT, February 1958. Average Height and Temperature, and Resultant Winds.



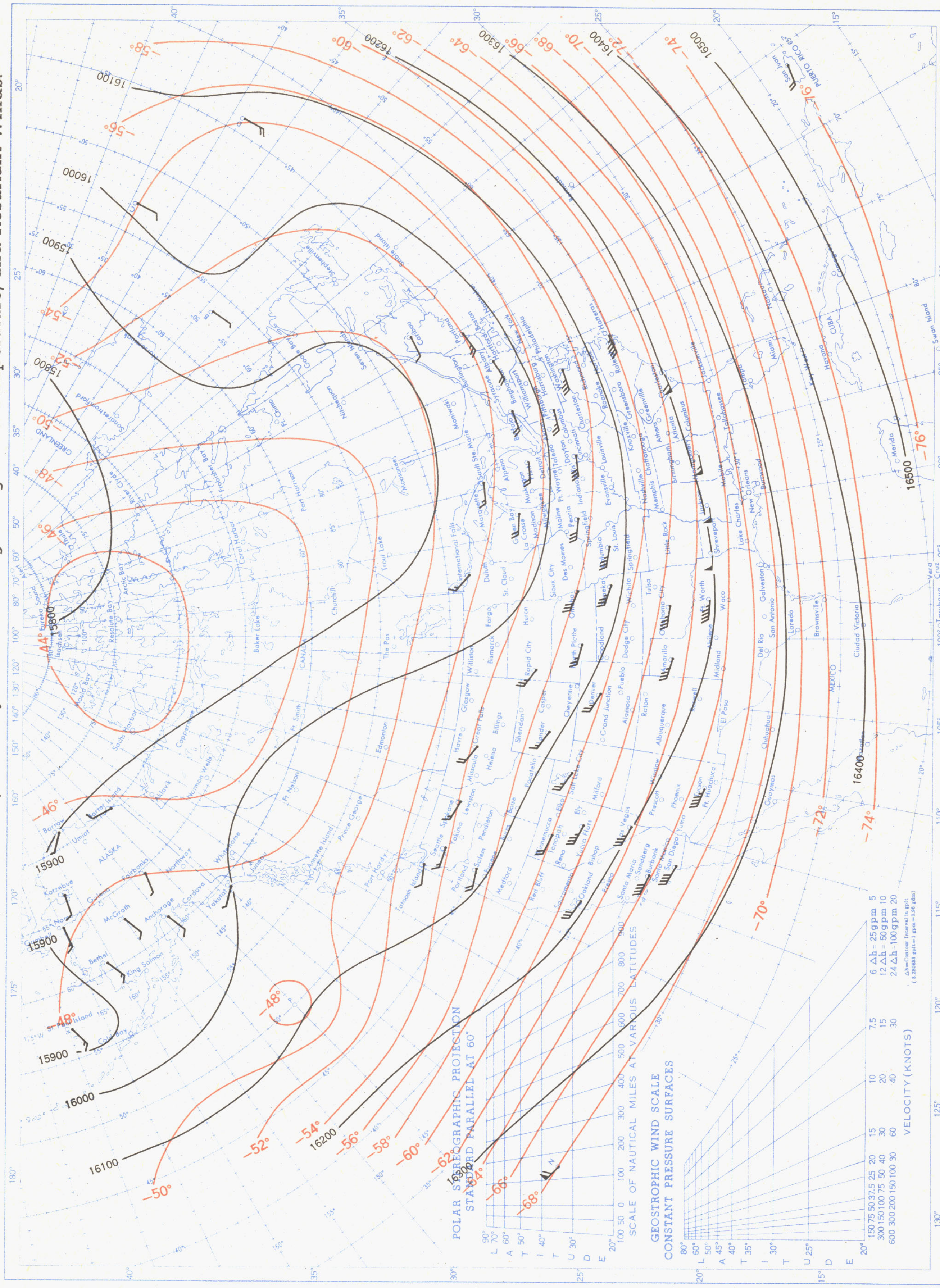
See Chart XII for explanation of map.

Chart XVI. 200-mb. Surface, 1200 GMT, February 1958. Average Height and Temperature, and Resultant Winds.



See Chart XII for explanation of map.

Chart XVII. 100-mb. Surface, 1200 GMT, February 1958. Average Height and Temperature, and Resultant Winds.



See Chart XII for explanation of map.